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MUTUAL ASSISTANCE BETWEEN COMMONWEALTH COUNTRIES

THE Commonwealth Trade and Economic Conference which met in Montreal during September 15–26 is of interest to scientists and technologists on several counts, not all of which are apparent from the brief report of the Conference which has been issued as a White Paper*. Telecommunications, though specialized, is a subject of obvious interest, and here the Conference agreed, in principle, on the basis of a recent report by the Commonwealth Telecommunications Board, that a round-the-world Commonwealth coaxial-cable telephone system should be constructed. If laid link-by-link the whole enterprise would probably take some ten years to complete, and might cost £88 million. Many technical problems remained to be solved, however, and apart from the financial questions still to be discussed, the Conference made no attempt to reach detailed or binding commitments.

This new enterprise, which has recently become technically possible, is expected, like earlier systems of communication, to strengthen Commonwealth associations and promote Commonwealth trade, and thus illustrates the way in which technology and science can assist the economic advance of peoples, in this case, the members of the British Commonwealth of Nations. That is notably true of research, and it is surprising that the report makes no mention of the announcement at Montreal by the United Kingdom Government that it is considering a proposal to establish, under the general control of a committee of the Privy Council, an Overseas Research Council, which would be concerned with research, particularly in the Commonwealth (*Nature* of November 22, p. 1413). In referring to this announcement, in a speech at Abingdon on October 20, the Lord President of the Council said that our existing organizations in industrial, medical and agricultural science would be made available to give assistance through the medium of this new body; this is an indication of the importance which the Government attaches to international research and follows on a powerful plea recently made by Mr. R. E. Casey, the Australian Minister for External Affairs (*Nature* of November 22, p. 1397), and further details will be awaited with interest.

At first sight it would appear that some care must be taken to avoid duplicating the work which is already being done through the Colonial Research Council, the Colonial Products Council, the Colonial Medical Research Committee, the Committee for Colonial Agricultural, Animal Health and Forestry Research and other bodies. The new body will obviously have a wider scope, so it may be presumed that before it begins to function a sufficiently clear indication will be given of its proposed relations to these bodies, so that informed criticism can be brought to bear before and not after duplication or waste of effort has occurred. It should be a prime purpose of any new organization to improve the means of communication so as to ensure that the most effective use is made of existing resources and information, and to avoid any diversion of the Commonwealth's severely limited resources of scientific and technical man-power into unproductive occupations.

It is obvious from the report that one purpose of the Montreal Conference in adopting these proposals is to enable the more prosperous members of the Commonwealth to contribute more effectively to the rapid advance of the less-developed countries. It is apparent from the latest report of the Consultative Committee of the Colombo Plan (p. 1718 of this issue) that there is increasingly general recognition that this is a matter for close collaboration between all Commonwealth countries and that the benefits are not all one way. The report emphasizes that it is of the utmost importance that the less-developed countries of the Commonwealth should succeed in implementing their development programmes, and the Conference agreed that, even to the extent of some sacrifice, all that is possible must be done to assist in the solution of these vital problems.

This problem of development, including technical assistance, is discussed at some length in a section of the report devoted to development, although in other sections also some measures intended to assist development, directly and indirectly, are indicated. The Conference recognized the importance of a broad joint effort on the part of Commonwealth countries to enable economic development to proceed as rapidly as possible in its under-developed countries, and it is seriously considered whether such development would be assisted by setting up a new institution such as a Commonwealth Development Bank. Methods of mobilizing resources for Commonwealth development are to be studied further; and meanwhile, although it was agreed that the present flexible and informal machinery for consultation is working well and is well-fitted to the character of the Commonwealth relationship, it was decided to co-ordinate these existing arrangements under the name of a Commonwealth Economic Consultative Committee. An offer by the United Kingdom Government to provide a Commonwealth House, to be available for the constituent bodies of the Council and for other Commonwealth meetings, was welcomed.

Possibly of even greater interest to the scientist than the announcement of the establishment of an Overseas Research Council, and certainly of equal

* Report of the Commonwealth Trade and Economic Conference. Pp. 17. (Cmnd. 539.) (London: H.M. Stationery Office, 1958.) 1s. net.

importance, is the agreement of the Conference both to establish a new scheme of Commonwealth scholarships and fellowships, and to convene a meeting early in 1959 to work out details of the new scheme, and also to consider what might be done to expand and improve mutual assistance between Commonwealth countries. Even from the point of view of technical assistance, the section on education is one of the most interesting and important in the report; but it is no less vital in regard to the problem of expansion and utilization of the Commonwealth's resources of trained man-power, upon which economic advance and indeed scarcity and prosperity depend in the United Kingdom and also elsewhere.

This view found wide support in the debate in the House of Lords on November 4 in reply to the Queen's speech. Baroness Elliot of Harwood, quoting the reference in that speech to the increasing association of peoples with the management of their own affairs, urged that education is fundamental, and is no less essential to the successful working of free democracy than to enable Britain to play a leading part in the twentieth-century world. Lord Soulbury, in particular, elaborated the theme, referring to the magnitude of the task of educating the multitudes of newly enfranchised electors in the countries which have become independent in the past decade, so that they should have some capacity for discrimination and criticism. Although social services such as education are the responsibility of these new independent governments themselves, the older countries could help by providing money, as through the Colonial Development and Welfare Fund, which up to last year had provided £36 million for this purpose, but still more by providing teachers.

All delegations at the Conference were agreed on the great importance of education and training as an indispensable condition of development, and the Commonwealth countries were manifestly resolved to help one another as much as possible in this field at all levels. In some countries, as Lord Soulbury indicated, the most pressing need at present is for primary education, for more teachers and for help in training them. Accelerated programmes to train foremen and technicians are also needed, as well as for new technical and other training institutions. Many of the universities in the Commonwealth would benefit from having the services for a few years of teachers from older institutions, and from being able to send to them some of the younger members of their staffs to serve temporarily as teachers. Apart from its educational value, this greater mobility and interchange would be of considerable value in the communication of ideas and the stimulation of research, and an increase in the number of scholarships and fellowships for tenure abroad and open to both undergraduate and postgraduate students would also help in that way, and in maintaining high standards of advanced study.

Much is already being done in this respect, apart from such special programmes as the Colombo Plan. More than 50,000 overseas students are already receiving instruction in Commonwealth countries—most of them from other Commonwealth countries—while there is a substantial flow of teachers and experts within the Commonwealth, and a large expansion in these facilities was already in prospect when the Conference met. The decision in principle to establish a new scheme of Commonwealth scholarships and fellowships was taken with the view of meeting the ever-increasing need for people equipped with general training to serve in all the varied processes of a complex society. Some of the new scholarships will be in the field of the humanities and the social sciences as well as the natural sciences, and will be designed to recognize and promote high standards of intellectual achievement, and others may be at various levels in the teaching field.

Within a few years of its inception, the programme is expected to cover some thousand scholars and fellows, of which the United Kingdom undertook to be responsible for one-half and Canada for one-quarter, while the Australian delegation has meanwhile announced an increase of 150 in the number of places made available for trainees under the technical co-operation programme of the Colombo Plan. The exact scope and detailed arrangements of the whole programme will be worked out after consultation with university and other educational authorities in Commonwealth countries at a meeting to be held in the United Kingdom early in 1959. The composition of this meeting remains to be determined. The meeting will also be asked to review existing arrangements for co-operation between Commonwealth countries in the field of education and to make recommendations for any improvement or expansion that may be possible, particularly in regard to the supply and training of teachers.

In welcoming the announcement of this new fellowship and scholarship scheme, Baroness Elliot hoped that it would be possible to make such scholarships available to all types of boys and girls and not only to those who might go to university and school staffs. She suggested that some exchanges might be made on the lines of those arranged very successfully by the National Federation of Young Farmers' Clubs and by the English Speaking Union. Lord Soulbury commented on the need to ensure that those seconded for educational service abroad should be assisted to obtain suitable posts on their return to Britain, and should not find that their professional prospects had suffered; and he referred also to the importance of the technician, in agriculture as well as in industry, and the bearing of elementary education on the effective use of the technical expert.

These are all particular facets or details of the whole problem, to which no doubt due attention will be given by the conference when it meets; and it may well be found that there is enough continuing work for it to develop, as Lord Soulbury suggested, into a permanent Commonwealth Council of Education, replacing the Imperial Education Committee which lapsed about 1930. Existing arrangements for educational interchange have grown up over a long period of years, and while there may be real advantages in their being in many hands, it may be useful to have some permanent co-ordinating or advisory body even if no adjustments are necessary to make

the existing arrangements correspond more closely to present needs. The broad subject has already engaged the attention of the Home Universities Conference, which in December 1957 discussed the subject of academic mobility at some length.

The proposed conference should certainly consider this in the slightly wider context of professional mobility in general. From what was said at the Home Universities' Conference in 1957, it seems likely that overseas representatives will ensure that due attention is given to some of the points, such as pensions schemes, where government action should be a decisive factor in removing some of the existing obstacles to mobility. That, of course, is one matter in which the British Government representatives should be ready to concert action; but in the meantime it is to be hoped that Dr. B. V. Bowden's plea for serious study of the technical aspects of the problem is receiving attention. Indeed, one of the most important tasks to be attempted before the conference meets is to ensure that the question of scholarships and fellowships is put in its proper perspective in relation to the training and supply of men and women of high ability, and the way in which their services can be most effectively used throughout the Commonwealth.

Attention to such factors as conditions of service may help to ease one aspect that has caused some concern in Britain, apart from putting such careers in a truer perspective. The third report of the Migration Board, to which the Earl of Albemarle directed attention in the House of Lords on November 20, has referred to an increased loss of skilled and professional workers, in terms of absolute numbers, with the upward trend of emigration, as the broad conclusions drawn from the Board's study of the statistics for 1956, while the dominating feature of United Kingdom emigration in 1957 was the exceptionally heavy flow to Canada. The Board, however, did not find any cause for present concern, and in a written reply to a question in the House of Commons on November 4, the Minister of Labour, Mr. Ian Macleod, claimed that the Civil Service Commission had reported that recruitment of British scientists in the United States and Canada for research fellowships had shown encouraging results.

Nevertheless, Sir John Cockcroft, speaking in Manchester on that day, expressed the fear that too many of the best of Britain's young scientists and future leaders would be attracted overseas by the better facilities and salaries which would result from the present expansion of basic scientific research. Sir John was pleading in this connexion for the more liberal endowment of university research with equipment and assistance. He suggested, in particular, that an increase of even 1 per cent in expenditure on research and development in this direction would pay handsome dividends and greatly help to maintain our position in the world.

However, it is not simply the aspect of salaries and the actual level of scholarships and fellowships that needs to be considered if the new scheme is to have its full effect. The availability of equipment for research and teaching, the ancillary facilities, whether technicians or even clerical staff, the provision of adequate library facilities, and questions of publication and conditions of service are all important; they bear no less on the efficient use of our limited resources of trained man-power than they do on its mobility, and on our capacity to ensure that the flow is in both directions, with all that is implied in this not merely for Britain but also for the whole Commonwealth. It was rightly said in the debates in Parliament that the new scheme represents a great challenge. It is a challenge not merely to teachers and educational authorities of the Commonwealth but also—perhaps especially—to scientists and technologists of the Commonwealth, to see that the issues raised are considered imaginatively and constructively. Full use must be made of an unrivalled opportunity to remove some of the existing obstacles to the utilization of scientific work and to promote an interchange of people and thought which will prove increasingly fruitful.

NUMERICAL METHODS IN FUNCTION-SPACE

The Hypercircle in Mathematical Physics

A Method for the Approximate Solution of Boundary Value Problems. By Prof. J. L. Synge. Pp. xii + 424. (Cambridge: At the University Press, 1957.) 70s. net.

PROF. SYNGE'S well-produced book provides a fascinating description of methods which he, with Prof. Prager, evolved to solve certain boundary value problems. It begins with a description of the geometry of function-space, and the claim that no specialized mathematical knowledge is required of the reader is for once true. The account of the properties of function-space theory in the first half of the book is not only clear and easy to read but also possesses an attractive style which makes the book difficult to put down once one has started to read it. What may well be fresh and unusual concepts to many readers are introduced so naturally, in small doses, that initial apprehensions are soon forgotten and one becomes eager only for more.

To find the solution to a boundary value problem requires the determination of the unique function which is common to the set of all functions satisfying the governing differential equation and to the set satisfying the boundary conditions; in the language of function-space, we have to find the unique point of intersection of two linear subspaces of infinite dimensionality. It is easy to build up within each of these subspaces constituent parts which are of finite dimensionality. These parts are themselves subspaces, which in general cannot be expected to intersect, but the common perpendicular of which is readily defined. It is proved that the unique point of intersection of the subspaces of infinite dimensionality lies on the hypercircle (the intersection of a hypersphere with a hyperplane) for which the shortest distance between the subspaces of finite dimensionality is a diameter. If the radius of the hypercircle is small then its centre is an approximation to the required point of intersection. Certain inequalities are also proved relating to the Dirichlet integral

(that is, in the torsion problem, to the torsional rigidity).

Prof. Synge illustrates the methods particularly by reference to the torsion problem. The theory of function-space is his means to attain the end of solving this and other problems within a known degree of approximation. His description of the means is so delightful that it is disappointing to find the numerical results in the end not so satisfying. The set of algebraic equations which has to be solved to determine the shortest distance between the subspaces of finite dimensionality, in the solution of a torsion problem, are closely similar to the set which is presented in the standard method using finite-difference approximations; but the values of the stress function which these equations yield, in the torsion of a hollow square (Fig. 4.58*a*), are suspect in that even their second differences are sufficient to show a marked lack of smoothness. Furthermore, the numerical assessment of the torsional rigidity, although placed between bounds, is, on the evidence also of results for the torsion of a hollow square, no better than, if indeed as good as, that derived from the simplest finite-difference approximations.

The book is stimulating, and valuable in that it offers a novel approach to the numerical solution of boundary value problems; one looks forward to further developments of its methods.

D. N. de G. Allen

SHIPS IN ROUGH WATERS

Ships in Rough Water

By J. L. Kent. (Nelson's Nautical Series.) Pp. xiv+287. (London: Thomas Nelson and Sons, Ltd., 1958.) 32*s*. 6*d*. net.

After devoting the whole of his professional career to the study of the performance of ships, Mr. J. L. Kent has written a book on a subject in which he is exceptionally well qualified. During his many years' experience of testing model ships, and research at the National Physical Laboratory, Mr. Kent not only attended numerous ship-trials under generally favourable conditions but also made ocean voyages on ships of various types with the express purpose of studying their behaviour in the varied and difficult conditions in which they normally operate.

This book is based on these experiences. It also contains a survey of theory and practice relating to the movement of sea and ships. There are three parts dealing respectively with ocean weather; behaviour of ships in a seaway; and resistance and propulsion of ships in rough water. Each part contains numerous references to relevant papers which have appeared over many years and the technical discussion is well illustrated. It is evident that the author has thoroughly searched the literature on his subject. The sub-division of the text is excellent. It is difficult to find any aspect of the performance of ships at sea which is not discussed, yet each is dealt with compactly so that the book is not unduly long. The outcome is a volume which is sufficiently technical to be of value to the owner, the designer and the student of ships, while it is written in language which is simple, direct and lucid so that it may be enjoyed by all who have a knowledge of and a love for the sea and ships.

The author is revealed as a person of exceptional powers of observation and acute memory for detail. Wherever possible he gives suggested explanations for phenomena observed which appear to require explaining. The critical reader may not always find himself in agreement with the explanations offered, but will be impressed by the exhaustive treatment and the very real effort to apply the knowledge gained to the improvement of the design of ships in relation to their behaviour at sea. The final chapter is devoted to summarizing the author's conclusions, and is noteworthy for its conciseness.

In recent years the attention of the tank experimenter has been given more and more to the investigation of the sea-keeping qualities of ships, and this change of emphasis from that on performance in smooth water is continuing. Mr. Kent does not refer specifically to this trend nor to the results of the more recent investigations into ocean weather and performance of ships at sea. However, this is not detrimental to the book, which is mainly a record of Mr. Kent's own experiences and ideas with supporting theory and experiment data, and in the preface he modestly indicates the need for greater knowledge. The world of naval architecture is indebted to Mr. Kent for putting into a single very readable volume his considered views on the design of ships for service conditions, no doubt matured by leisurely reflexion in retirement.

GEOGRAPHICAL ANALYSIS OF BRITISH WEATHER

British Weather in Maps

By James A. Taylor and R. A. Yates. Pp. xiv+256. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 21*s*. net.

This is an attractively produced book the elegance of which does great credit to its printers and publishers. The authors, who lecture in the Department of Geography at Aberystwyth, define their purpose (p. 39): "the interpretation of the Daily Weather Report for the non-meteorologist and in particular of (*sic*) the geographer"; elsewhere, "a method of geographical analysis and interpretation of the primary documents of British weather". Introductory chapters discuss fundamentals of British weather, the compilation of the Daily Weather Report, and the prevailing characteristics of air masses. Thereafter the method is to present well-chosen examples of representative situations, and then to plot weather elements separately and examine their distribution. Upper-air data are mentioned, but stress is on the surface map.

The authors' approach is original, and without doubt this compilation is useful, although it will meet with some criticism from both geographers and meteorologists. Geographers will note the difficulties arising from plotting temperature using 6-hr. data and from the omission of upland stations (cf. p. 198). After reading p. 66 the student will be much puzzled by events at Benbecula and Tiree on Fig. 37; and (p. 90) the weather at Dishforth (Fig. 40) is scarcely anomalous under the conditions given. To a geographer, Cape Wrath is not in the Hebrides (p. 207) and West Freugh is not in the Southern Uplands (p. 96). Meteorologists will not care much for the method and will find their own points to criticize, for example, on pp. 55 and 63 relative and absolute humidity are confused; "the slower rate of cooling at coastal stations" (p. 190) is not well supported by Fig. 70. Noon observations would have made for

better discussion ; the transitional character of most of our air might have been emphasized more.

There are, however, many admirable diagrams and maps to enliven the reader ; for example, those showing visibility (cf. p. 211), cloud and pressure tendency ; and while alert-minded students may here and there ask awkward questions, it is good for geographers to be reminded of orographic depressions. Hence, the book will go far to fulfil its purpose ; any student who works through this book will gain considerable insight into synoptic meteorology, and will be well equipped to add to his knowledge of British hill weather from other sources. GORDON MANLEY

INDUSTRY AND THE WORKER

The First Principles of Industrial Relations

By Dr. A. E. C. Hare. Pp. vii+146. (London : Macmillan and Co., Ltd. ; New York : St. Martin's Press, Inc., 1958.) 12*s*. 6*d*. net.

Productivity and Economic Incentives

By J. P. Davison, P. Sargant Florence, Barbara Gray and N. S. Ross. Pp. 306. (London : George Allen and Unwin, Ltd., 1958.) 35*s*. net.

AN economist, Dr. A. E. C. Hare, of the University of Leeds, has written a book on industrial relations which may well become a little classic. Using knowledge gained from the study of economics, psychology, sociology and law in his quest to find the source of industrial discontents, his book ranges over the whole structure of society, its social organizations and political forms, its religious and ethical norms and its attitudes to property and work. Yet all the time Hare is concerned with those features of industrial relations which make for workers proud of their callings, satisfied with their rewards, and secure in the knowledge that they belong to efficient firms with executives who genuinely believe that good profits and sound industrial relations go hand-in-hand.

Dr. Hare shows, for example, that the common attitude of connecting the development of good industrial relations simply with the avoidance of strikes is a negative approach which begs many questions and leads to more and more industrial unrest. The study of industrial relations should take full account of the assumptions fundamental in the structure of society ; the freedom of the individual in thought and speech and of his right to organize with groups of like-minded people for religious, political or economic purposes ; the freedom of the individual to buy and sell and to enter any occupation he chooses ; the freedom for a man to strive to increase his income and to acquire wealth and so lift his status in the eyes of his fellow-men ; the right of a man to acquire and own property and to dispose of it as he pleases. These are fundamental freedoms which give rise to conflicts between themselves ; freedom in one direction may have to be restricted in order to permit freedom in another. "The conflicts which arise in industry are the products of a conflict between individuals or groups, each pursuing their economic freedom to increase their income. They also arise from the conflict between the freedom to own and direct how the instruments of production shall be used and the economic freedom to work at any occupation or indeed to work at all. Freedom to direct how the means of production shall be used carries with it economic control over the lives of men and must therefore necessarily conflict not only with their economic freedom but also with many other individual freedoms."

Here lies the root of the problems of industrial relations and, in this masterly little book, which is a model of clear thinking, Hare shows how the State, the employer and the trade unions each have a contribution to make in the never-ceasing struggle to establish industrial harmony. He is wise enough to show that there are no quick or easy remedies based on the latest device.

In his analysis Hare does not minimize the part played by wages as a major cause of industrial discontent ; more disputes arise in industry over wages than any other subject. Yet, as the authors of "Productivity and Economic Incentives" show, surprisingly little attention has been paid to the real effects of the economic motive in industry. Industry ceases to be unless it can produce efficiently, but even to-day there is little knowledge of how productivity is affected by the introduction of financial incentive schemes. This has been partly due to the difficulty of obtaining clear cases of an incentive applied in isolation, and partly to the neglect of the subject by psychologists. They have been, as Sargant Florence writes, "only slightly interested in tracing the economic motive or observing the material, economic facts of output, costs, absence and labour turnover".

This composite book has been written by four authors, all members of the Faculty of Commerce and Social Science at the University of Birmingham. The background is described by Prof. Sargant Florence, while J. P. Davison, after measuring their output and earnings, interviewed factory workers to determine their reaction to incentive payment schemes and ancillary matters. These accounts are supplemented by Dr. H. S. Ross, himself a former convener of factory shop stewards, who also supplies a detailed and over-long case-study of trades union and labour reactions to the application of incentives and the industrial relations background in a chosen factory. Dr. Barbara Gray interviewed and obtained the output earnings of laundry workers and shop assistants.

The conclusions of all four investigators were unanimous and clear. The introduction of financial incentive schemes in industry and commerce leads to a considerable increase in the productivity of labour together with an increase in earnings without the workers complaining of undue strain. Few there would be with knowledge of industry who would question the findings of these well-conceived and well-conducted inquiries. Few would argue against their considerable extension.

How, therefore, can their findings be reconciled with the actions of several leading British firms which, during the past few years, have abandoned their piece-work incentive schemes ?

It is perhaps significant that those who are advocating the abolition of financial incentive payment schemes are those employed by companies which were among the first to introduce these schemes several decades ago and where they had reached a considerable degree of complexity. The reconciliation of this view—which has led to the abolition of financial incentive schemes in such companies as Ford and Vauxhall—and that put forward by the authors of the book may be due to two reasons. The first is that all factories striving to be efficient must introduce some kind of incentive scheme to determine its optimum rate of output ; it is difficult to see how a

norm can be established in any other way. The second is that the apparent success of changing from a flat rate of pay system to an incentive scheme or vice versa may be due not to the system of payment at all but to the change; it will be interesting to see whether in a few years time a new management at Ford or Vauxhall may decide the time has come for a change and revert to an incentive system of payment but worked out on lines different from those which formerly prevailed. T. H. Hawkins

LIBRARIES FOR RESEARCH

Classification and Indexing in Science

By B. C. Vickery. Pp. xvii+185. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 25*s.*; 5.50 dollars.

In a recent address in Manchester to the Reference and Special Libraries Section of the Library Association, Mr. D. J. Foskett said that it was intolerable that existing discords between the general classification system and the requirements of modern research should be allowed to continue, and urged the need to adopt new systems as they become necessary so that the results of research can be organized in a way that permits of their effective retrieval. Mr. B. C. Vickery's book, to which Mr. Foskett contributes an introduction, is intended as a contribution to that end. It does not purport to be a manual of classification and indexing but is intended rather to assist those who are concerned with the practical task of constructing systems for retrieving information, whether their concern is limited to classification and indexing or also embraces mechanical selection.

As such this book is primarily a study of method. It considers, step by step, the problems which arise in constructing a faceted classification and then discusses in some detail notational devices which may be used in a classified catalogue. A further chapter considers the new developments in the use of mechanical methods of retrieving information, and discusses the limitations of conventional systems of classification and indexing for this purpose, as well as the capacities of the machines. Due weight is given to the cost aspect, and the reader who follows Mr. Vickery's counsel will not prescribe a sledge-hammer to crush a nut. Finally, after a chapter in which indexing is considered from various points of view, particularly the use of facet analysis to overcome defects in alphabetical indexing, the future trends in information retrieval are briefly outlined, and some of the areas in which further study is required are indicated.

All this is competently and modestly done with no attempt to dogmatize. But the book has a much wider interest than for the specialist. In an opening chapter on the need for classification, Mr. Vickery amplifies the thesis that all forms of information retrieval can and should be based upon a classification of knowledge if they are to function with maximum effectiveness. With the needs of the user firmly in mind, Mr. Vickery sets forth very clearly the difficulties and problems that arise and his exposition should be of real interest to any scientist who is concerned with the problem of indexing and classification in his own particular field. For the most part this is done with admirable lucidity, but for the general reader the explanation of the technique of facet analysis could be clearer, and in view of the general interest of this chapter, Mr. Vickery might with advantage amplify it in a future edition. Also of general interest are the appendix on historical aspects of the classification of science and that giving a theoretical analysis of some general catagories useful in the classification of science. A series of admirable bibliographies enhances the value of the various chapters. R. Brightman

TREE PHYSIOLOGY

The Physiology of Forest Trees

A Symposium held at the Harvard Forest, April, 1957. Edited by Prof. Kenneth V. Thimann, with the assistance of William B. Critchfield and Martin H. Zimmermann. Pp. xvi+678. (New York: The Ronald Press Company, 1958.) 12 dollars.

The study of tree physiology as a separate branch of plant physiology has been traditionally confined largely to those problems of flow of sap, translocation and growth which assume particular significance in large woody perennials. In recent years, however, interest in the physiology of forest tree species at all stages of growth has grown considerably; besides a rapidly expanding fundamental research programme in forestry, many pure botanists have realized that here is a field which has been relatively little investigated in the light of modern physiological knowledge and techniques. The result has been an impressive expansion of our knowledge concerning tree growth which, until recently, has found little opportunity for collective expression. It was therefore a timely decision on the part of the Cabot Foundation for Botanical Research to arrange this the first international symposium on tree physiology. The publication of the thirty-five papers presented by invited participants provides a wealth of up-to-date information on a variety of topics, covering water relations and sap movement, photosynthesis, biochemistry, mineral nutrition, phloem transport, root growth, photoperiodism, reproduction and various other growth phenomena. Full discussions included with each paper serve as a particularly valuable source of comment, criticism and speculation.

Many of the contributions are primarily of academic interest, others of considerable practical significance in their application to sylviculture and tree breeding. The contents are therefore of interest to both botanists and foresters, and to single out particular papers as being more worthy of mention than others is a difficult task. Students of the classical physiological problems will welcome Scholander's elegant approach to the solution of the air embolism problem confronting the 'cohesion theory', and the articles of Huber and of Zimmermann dealing with phloem transport and the evidence for 'mass flow'. The various papers on photoperiodic responses, despite a certain overlap, and those on factors governing seed germination are well worth reading for both their botanical and forestry interest. Forest geneticists should certainly be stimulated by the papers discussing techniques for inducing early flowering.

On the whole, the publication maintains an excellent standard both as to contents and their reproduction. Despite its wide coverage, it leaves many important problems of tree growth untouched and raises many new ones; but, in filling at least partially a long-felt gap in our knowledge as to how trees function, it deserves, and will undoubtedly receive, a welcome reception. L. Leyton

AIR SHOWERS OF SIZE GREATER THAN 10^5 PARTICLES*

(4) THE DISTRIBUTION OF NUCLEAR-ACTIVE PARTICLES AND OF MU-MESONS

By J. A. LEHANE, Dr. D. D. MILLAR and M. H. RATHGEBER

The F.B.S. Falkiner Nuclear Research and Adolph Basser Computing Laboratories, School of Physics†, University of Sydney

THE importance of the nuclear-active cascade in the development through the atmosphere of an extensive shower of cosmic rays is now well established, although the details of the high-energy nucleon – nucleus interactions which generate the cascade are still largely unknown. Indeed, only from observations on the extensive air showers can one hope to gain insight into such high-energy phenomena.

Among the different types of particles in an air shower the nuclear-active particles, both nucleons and π-mesons, are produced directly in these nuclear interactions. The μ-mesons are produced at one stage removed from them by the decay of π-mesons. Investigations of these components are therefore likely to be of greater value in elucidating the nature of the interactions than are investigations of the electron component, since this last is detected after many generations of the electron-photon cascades which have been initiated by the decay of neutral π-mesons.

The experiment reported in this article was carried out in the University of Sydney (40 m. above sea-level). It was designed to determine the lateral distribution of the density of nuclear-active particles (which we shall refer to as 'nucleons' hereafter, although it must be understood that charged π-mesons are included in the term) and of μ-mesons, in air showers the measured sizes of which range from 3×10^4 to 6×10^6 charged particles. The distributions were determined for distances from the shower core of up to 50 m.

The results are consistent with earlier experiments and confirm quantitatively the fact that small showers are relatively richer both in nucleons and μ-mesons than are large showers[1]. The experimental observations at sea-level are compared with similar observations made by Vavilov *et al.*[2] at an altitude of 3,860 m., and the implications of this comparison are briefly discussed. From both sets of results we obtain figures which may be compared with the theoretical calculation of Ueda and Ogita[3] for a primary energy of 10^{15} eV. and best agreement is obtained for an inelasticity of 0·3 in the nuclear collisions, meaning that only 30 per cent of the energy of the primary particle is lost to secondary particles in each collision. However, no existing theoretical calculation of the development of the mixed cascade can yet be shown to account for all the experimental results, and it is suggested that the results are now sufficient in quantity for an extended programme of theoretical computation to be worth while.

* Preceding articles in this series appeared in *Nature*, **182**, 905, 973 and 1053 (1958).

† Also supported by the Nuclear Research Foundation within the University of Sydney.

Experimental Arrangement

A penetrating-particle detector has been included in the University of Sydney's array of scintillation counters used for the detection and analysis of extensive air showers. The array and the method of analysis of the results obtained from it, whereby the size and location of the core of each shower are determined, have already been described[4].

The construction of the penetrating-particle detector is shown diagrammatically in Fig. 1. It consists of three trays, one above the other, each containing 46 Maze-type Geiger counters, of length 50 cm. and diameter 2 cm., embedded in a lead pile. Above the topmost tray is 15 cm. of lead and 1·25 cm. of iron and between the trays is 5 cm. of lead and 1·25 cm. of iron. On the bottom is a layer of lead 2·5 cm. thick. Any particle entering the side of the pile without scattering must traverse at least 15 cm. of lead in order to be detected.

Each counter is connected to its own coincidence and memory unit, a two-grid thyratron, the condition of which determines whether or not a particle has traversed the counter in coincidence with an air shower detected by the scintillator array. The stored information from all the counters in the penetrating-particle detector is punched on paper tape which may then be examined visually or analysed by the electronic computer SILLIAC.

Classification of Events

The distinction between events caused by an incident μ-meson and by a nucleon is in principle simple. A μ-meson, provided it has an energy greater than 380 MeV., will traverse all three counter trays and discharge three colinear counters, one in each tray. A nucleon, on the other hand, will interact in the lead or the iron, producing secondary particles

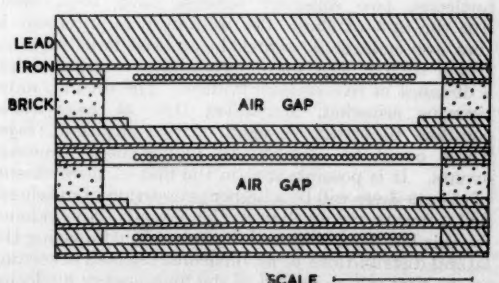


Fig. 1. Construction of the penetrating-particle detector

which will discharge several counters. The lower limit to the energy of such nucleons is not well defined by the number of counters discharged but is likely to be of the order of several GeV. (ref. 5). The electrons of the air shower are stopped by the shielding material. This classification into μ-meson, and nucleon, events is, however, liable to be affected in the following ways.

A μ-meson traversing a tray of counters may be accompanied by a knock-on electron which traverses a second counter in the tray, thereby simulating a low-energy nuclear interaction. The magnitude of this effect was determined in a subsidiary experiment in which 'straight-through' μ-mesons of the normal cosmic-ray flux which traversed the detector were selected by a counter telescope, the output from which was used to trigger the recording apparatus. The number of events in which one adjacent counter was struck, in addition to the three collinear counters traversed by the μ-meson, was found to be a fraction $0{\cdot}11 \pm 0{\cdot}01$ of the number of traversals. For the air-shower events the corresponding fraction was $0{\cdot}12 \pm 0{\cdot}02$ of the events in which three collinear counters were traversed. In view of this agreement, all events in which one counter was struck in one tray adjacent to the counters defining the trajectory of the μ-meson were classified as 'μ-meson induced'.

Because of the thickness of the walls of the counters, there exists a geometrical inefficiency for detection of particles. The subsidiary experiment mentioned above showed that there was a 10 per cent probability that a μ-meson traversing the detector would fail to traverse the sensitive volume of a counter in one of the trays, a result in agreement with the geometry of the trays. Consequently it was decided to accept as μ-meson events those in which only one counter in each of two trays was traversed, provided the supposed μ-meson trajectory was not inclined at an angle greater than about 40 deg. to the vertical. No correction was applied to the observed number of μ-mesons for those events which missed detection in more than one tray, since their number should be less than 1 per cent of the total number of observed μ-mesons.

Also omitted from the μ-meson class of events were those μ-mesons which produced knock-on showers discharging several counters and therefore were classified as nucleon events. From the subsidiary experiment mentioned earlier such events produced by the penetrating cosmic-ray flux, and which therefore included a contribution from genuine nucleons, occurred with a frequency less than 1 per cent of the μ-meson traversals. No correction has therefore been made for such events.

In selecting the events induced by the interacting nucleons, two different criteria have been used. For the first of these, the minimum requirement is that one counter be struck in at least two trays together with at least one non-adjacent counter within a distance of five counter widths. The second, more rigorous criterion, demanded that at least three counters be struck in each of two adjacent trays. These could be ascribed to higher-energy nucleon events. It is possible that in the first of these classes of events there will be a higher proportion of misclassified μ-meson events than in the second. No evidence for this has been observed, however, in comparing the lateral distributions of all nucleons, selected according to the first criterion, and of the high-energy nucleons, selected according to the second.

It is possible for a μ-meson and a nucleon to traverse the apparatus together, and frequently such events were indeed observed. However, in no single nucleon event is it possible to exclude the presence of a μ-meson traversal masked by the nucleon interaction. Rather than carry out the statistical procedure necessary to make use of such double events, the μ-meson distributions were obtained by excluding from the analysis all showers accompanied by nucleon events. It is thereby assumed that the μ-mesons and nucleons are spatially uncorrelated.

An incident nucleon may pass through the detector without undergoing any detectable interaction. The mean free path for interaction has been taken as 160 gm. cm.$^{-2}$ in lead and 130 gm. cm.$^{-2}$ in iron, and it is estimated that one-sixth of the nucleons will therefore traverse the detector without interacting. Of these, we have assumed that some 60 per cent are charged particles[6] which will be then wrongly classified as μ-mesons. In deducing the distributions of μ-mesons, 10 per cent of the corresponding nucleon density has accordingly been subtracted from that of the μ-mesons at each distance from the shower core. This correction may in fact be too small, since a non-interacting proton of energy 600 MeV. may traverse the detector simulating a μ-meson, whereas an interacting nucleon must have an energy of several GeV. to produce a detectable interaction. The true μ-meson distribution may therefore be even flatter near the shower core than we find.

Analysis of Results

A total of 3,240 showers was available for which the shower size and the location of the core were determined, the former to within limits of + 20 per cent and − 10 per cent, the latter with an uncertainty about ± 4 m. These showers were classified in 25 groups—in five ranges of shower size from 0·1 to 1, 1 to 3, 3 to 6, 6 to 10 and 10 to 60 × 10^5 particles—and in five ranges of distance of the penetrating particle detector from the shower core—from 0 to 50 m., in 10 m. intervals. For each of the 25 groups the mean shower size, N_i ($i = 1, \ldots, 5$), and the mean distance from the core, r_j ($j = 1, \ldots, 5$), were determined.

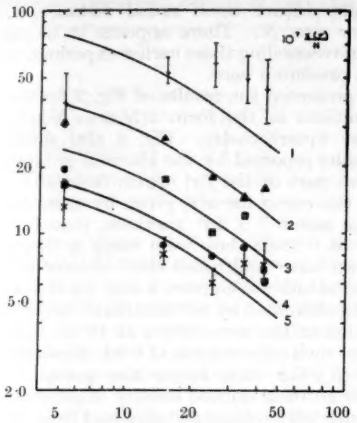
If for a class of showers, all of size N_i, the density of μ-mesons or of nucleons at a distance r_j from the core be denoted by x_{ij}, then the probability of observing m_{ij} showers in which one or more of the particles under consideration has traversed the detector, and n_{ij} showers in which no particle has traversed it, is proportional to :

$$P(m_{ij},n_{ij}) = [1 - \exp(-Ax_{ij})]^{m_{ij}} [\exp(-Ax_{ij})]^{n_{ij}}$$

where A is taken as the area of one of the trays of Geiger counters for μ-mesons, and as five-sixths of this area for nucleons, thus taking into account the probability for interaction by the nucleons discussed above.

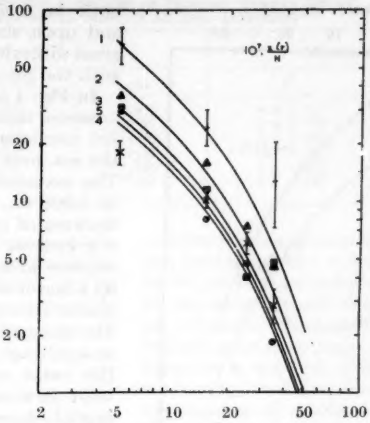
Using the values of m_{ij} and n_{ij} determined experimentally, this probability function was computed, as a function of the variable x, for each of the 25 groups of showers and the probability distributions were drawn. From these were determined the median values of x and the quartile values.

In Figs. 2 and 3 are plotted the median values of x_{ij} in particles per square metre divided by N_i, the mean shower size, as a function of r_j in metres. The error limits shown are typical for all points and correspond to the quartile value of the distributions



Distance from shower core, r (metres)

Fig. 2



Distance from shower core, r (metres)

Fig. 3

Fig. 2. Density of μ-mesons $x(r)$ in particles/m.^{2} divided by the mean shower size in scintillator particles as a function of distance from the shower core r in metres. (+ denotes showers of mean size $\bar{N} = 6{\cdot}2 \times 10^4$; △, $1{\cdot}9 \times 10^5$; ⊡, $4{\cdot}4 \times 10^5$; ⊙, $7{\cdot}8 \times 10^5$; ×, $1{\cdot}8 \times 10^6$)

Fig. 3. Density of nucleons shown in the same way as for μ-mesons in Fig. 2

in x. These limits then correspond to probable errors. In Fig. 2 the derived density of μ-mesons has been corrected at each distance for contamination by non-interacting charged nucleons by subtracting from it 10 per cent of the corresponding nucleon density as given in Fig. 3.

It is clear that the statistics are not yet good enough to determine whether there is a change in the shape of the functions for μ-mesons and nucleons relating x/N and r as the shower size increases. It is also clear, however, that for any fixed distance from the core the ratio x/N increases with decreasing N: small showers are relatively richer in both μ-mesons and nucleons than are large ones.

The curves which have been fitted to the points of Figs. 2 and 3 were deduced as follows. It was assumed that the density of both μ-mesons and of nucleons was expressible in the form $x(r) = N_i f(r)$. For each of the five mean distances, r_j, the expression $\prod_{i=1}^{5} P(m_{ij},n_{ij})$ was computed as a function of f, and from the probability distributions so obtained the median values and the quartile values of f were again obtained for each distance r_j. The radial distributions so obtained were plotted for μ-mesons and for nucleons. Again, 10 per cent of the nucleon ordinates were subtracted from the μ-meson ordinates at each distance. A smooth curve was drawn through these points. These curves were then fitted to the points of Figs. 2 and 3, using the computed probability distributions in x_{ij} by a maximum likelihood method.

As a second approximation it was assumed that $x(N,r) = Nk(N)f(r)$, where $k(N)$ is a slowly varying function of N, and is in fact given by the separation of the curves of Figs. 2 and 3. These values of $k(N)$ as a function of N are plotted in Figs. 4 and 5, taking in each case $k(N) = 1$ for a shower size $N = 10^6$ particles. The errors quoted on the values of $k(N)$ are probable errors derived in the curve-fitting procedure. Taking these values of $k(N_i)$ and putting $x(N_i,r_j) = N_i k(N_i) f(r_j)$, the expression $\prod_{i=1}^{5} P(m_{ij},n_{ij})$ was again computed as a function of $f(r_j)$. The probability distributions were again plotted, and median and quartile values of f determined for each r_j. These values of $f(r)$ are plotted in Figs. 4 and 5 for μ-mesons and nucleons. Again the μ-meson ordinates have been corrected by 10 per cent of the nucleon ordinates at each distance. The calculated values of $f(r)$ so obtained were consistently about 10 per cent greater than those already obtained by averaging over showers of all sizes. This similarity in shape of the distribution curves at the two levels of approximation arises from the fact that the shower-size distributions in each distance class were similar.

In Fig. 5 we have also plotted the lateral distribution function for the high-energy nucleons. Because of limited statistics only the first approximation procedure was adopted. There is no significant difference between the two distributions. The curves drawn through the nucleon points have the analytical form $f(r) = A\exp(-r/20)\, r^{-1/2}$ with $A = 7{\cdot}5 \times 10^{-6}$ for the total nucleons, 3×10^{-6} for the high-energy nucleons.

If then the density of μ-mesons and of nucleons may be expressed in the form $x(N,r) = N\,k(N)\,f(r)$, so that the radial part of the distribution $f(r)$ is independent of N, then the curves of Figs. 4 and 5, giving $k(N)$ as a function of N, and $f(r)$ as a function of r, define x.

Discussion

From the experimental results presented in Figs. 2 and 3 one finds that, at a distance of 5 m. from the

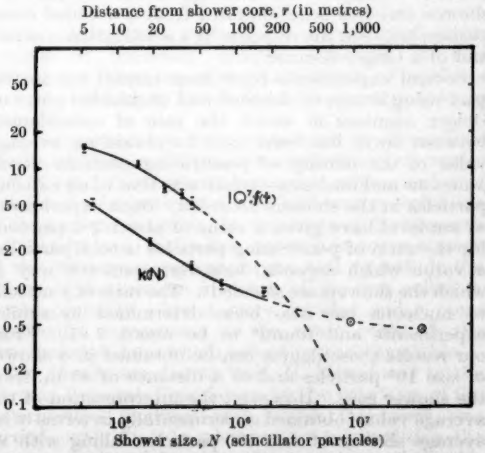


Fig. 4. Density of μ-mesons expressed as a function of shower size, N (scintillator particles), and the distance from the shower core, r, in metres. The density of μ-mesons is given by $x(N,r) = N\,k(N)\,f(r)$ per sq. metre. The extrapolated part of the curves are obtained from the Harwell observations

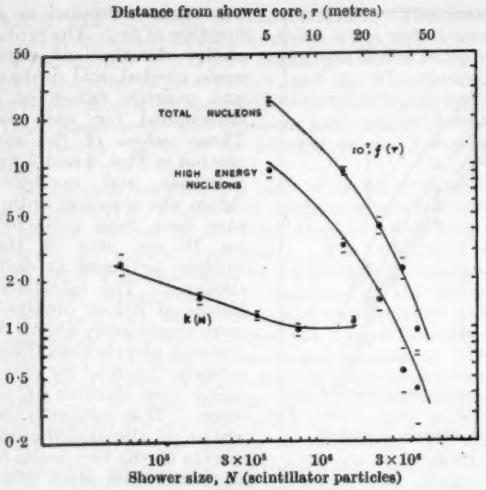


Fig. 5. Density of nucleons expressed in the same way as for the μ-mesons of Fig. 4. High-energy nucleons are those for which the minimum number of Geiger counters discharged is greater than for the total nucleons

shower core and in a shower of size 10^5 particles the density of nucleons and of μ-mesons are both $\approx 0{\cdot}5$ m.$^{-2}$. The total particle density, estimated from our shower structure function[4], is 35 m.$^{-2}$. For a 10^6-particle shower, on the other hand, the densities of nucleons, μ-mesons and total ionizing particles are respectively 3, 1·7 and 350 m.$^{-2}$. Since these nucleon densities refer to nucleons detected by our apparatus and therefore having energies greater than several GeV. (and this lower limit may be as high as 10 GeV.) we should expect a density of low-energy nucleons appreciably higher than these quoted values. Such low-energy nucleons would then constitute an appreciable fraction of the total particle density near the core and may be expected to play a significant part in determining the form of the shower-structure function of all ionizing particles near the core. Further evidence confirming the existence of a high relative density of lower-energy nucleons near the shower core has been obtained from a detailed comparison between the response of a scintillation counter and of a Geiger counter[7].

Several experiments have been carried out in the past using arrays of shielded and unshielded trays of Geiger counters in which the rate of coincidences between trays has been used to obtain an average value of the density of penetrating particles—both μ-mesons and nucleons—relative to that of all ionizing particles in the showers recorded. Such experiments at sea-level have given a value of about 2·5 per cent for the ratio of penetrating particles to total particles, a value which depends, however, upon the way in which the showers are selected[8]. The ratio of μ-mesons to nucleons has also been determined in similar experiments and found[9] to be about 2 : 1. From our results these figures can be obtained in a shower of size 10^6 particles and at a distance of 40 m. from the shower core. However, the interpretation of the average values obtained experimentally in terms of an average shower of size 10^6 particles falling with its core 40 m. away from the detecting apparatus is not particularly significant, since the shower-structure functions for μ-mesons, for nucleons, and for total particles in a shower differ from each other markedly, both in their dependence upon radial distance, r, and upon shower size, N. There appears to be no great difficulty in reconciling these earlier experiments with the results presented here.

In Fig. 4 are presented the results of Fig. 2 for the μ-meson distributions in the form $x(N,r) = N\,k(N)\,f(r)$ particles per square metre. Fig. 4 also shows the sea-level results reported by the Harwell group[10]. The extrapolated part of the $f(r)$ curve, from 40 m. to 1,000 m., is the curve for $x(r)$ given by them for showers of mean size $6{\cdot}7 \times 10^6$ particles, joined to our own at 40 m. Since they were using a Geiger counter array we have multiplied their shower size by a factor of 1·4 in order to convert it into the shower size as it would be estimated by our scintillator array[11]. The normalization of the two curves at 40 m. leads to a value of k for such a shower size of 0·52. Similarly, the value of $k(N)$ for their larger size group has been obtained from their quoted density of μ-mesons in such showers at 100 m. from the core and from the $f(r)$ value at this distance as given by the extrapolated curve of Fig. 4. The radial distributions given by the Harwell group for the two mean shower sizes do not differ in form significantly from each other.

The results from Harwell on the density distribution of nucleons is of limited statistical significance since their shower cores are located with large uncertainty. However, they do obtain an estimate of the total number of nucleons detected, from the total number of nucleon events detected in showers of mean size $6{\cdot}7 \times 10^6$ charged particles. Their estimated number is $(4 \pm 2) \times 10^4$. Integration of our analytical-structure function leads to a predicted number in such showers of $3{\cdot}8 \times 10^4\ k(N)$ of total nucleons, of which five-sixths would be observed to interact in a detector such as our own.

One may consider the data of Figs. 4 and 5 merely as a convenient way of representing the experimental observations. If, on the other hand, it is assumed that the shape of the distribution function $f(r)$ is strictly independent of shower size N then the total numbers of nucleons and of μ-mesons are proportional to $Nk(N)$. We then find from the results presented in Figs. 4 and 5 that the total number of nucleons in showers of size 6×10^4 to 8×10^5 is proportional to $N^{0{\cdot}6 \pm 0{\cdot}1}$, whereas for μ-mesons it is proportional to $N^{0{\cdot}4 \pm 0{\cdot}1}$. From the additional μ-meson data of the Harwell group there is evidence that the exponent in the relation may increase at large values of N.

Experiments very similar to our own have been carried out at an altitude of 3,860 m. in the Pamirs by Vavilov *et al.*[3], and it is of interest to compare the results obtained at the two altitudes. In showers of size less than 2×10^5 they find the number of nucleons to be proportional to $N^{0{\cdot}2}$ and for larger sizes it is proportional to $N^{1{\cdot}0}$. The change which occurs at a shower size of 2×10^5 particles they interpret as indicating a change in the nature of the high-energy interaction at an energy of 10^{15} eV., their estimate of the primary energy of such a shower. If this were so we might expect that our sea-level showers of size greater than 2×10^5 particles, initiated by higher energy primaries, would contain nucleon numbers proportional to $N^{1{\cdot}0}$ rather than $N^{0{\cdot}4}$. The interpretation given above of the results from the Pamirs is not, therefore, likely to be correct.

In comparing further the results obtained at sea-level and at mountain altitudes we may take the number of nucleons at sea-level, n_1, in a shower of size N_1 to be proportional to $N_1^{7/4}$, and at mountain altitudes the corresponding numbers of nucleons, n_2,

Table 1. THEORETICAL RESULTS OF UEDA AND OGITA FOR A SHOWER OF PRIMARY ENERGY 10^{15} EV., COMPARED WITH THE CORRESPONDING EXPERIMENTAL RESULTS AT TWO ALTITUDES

	Sea-level, 1,030 gm. cm.$^{-2}$			Mountain altitude, 640 gm. cm.$^{-2}$		
η =	N	n_{nucleons}	n_μ	N	n_{nucleons}	n_μ
0·3	$3{\cdot}6 \times 10^5$	1,900	4,500	$7{\cdot}8 \times 10^5$	2,300	2,300
Experimental	$5{\cdot}0 \times 10^5$	2,100	0·65	$7{\cdot}8 \times 10^5$	2,100	0·48
0·5	$2{\cdot}4 \times 10^5$	450	7,000	$9{\cdot}7 \times 10^5$	1,800	6,000
Experimental	$3{\cdot}4 \times 10^4$	1,600	0·54	$9{\cdot}7 \times 10^5$	2,900	0·56
1·0	$1{\cdot}3 \times 10^5$	100	8,700	$1{\cdot}3 \times 10^6$	1,000	8,000
Experimental	$1{\cdot}8 \times 10^5$	1,000	0·43	$1{\cdot}3 \times 10^6$	3,900	0·74

as proportional to $N_2^{\gamma_2}$. Then if the shower size is attenuated by a factor A between these two altitudes, so that $N_2 = AN_1$, we find that the nucleons will be attenuated by a factor n_2/n_1, which is proportional to $A^{\gamma_2}N_1^{\gamma_2-\gamma_1}$. The attenuation factor, A, appears to be independent of shower size and, corresponding to constant attenuation length of 190 gm./cm.^{2} (ref. 12), is equal to 8. We find from our results that $\gamma_1 = 0{\cdot}6 \pm 0{\cdot}1$, and from the Pamirs results for the corresponding showers eight times the size of our own, that $\gamma_2 = 1{\cdot}0 \pm 0{\cdot}1$. The attenuation factor for the nucleons is thus dependent on shower size to the extent that $\gamma_2 - \gamma_1$ may be considered different from zero. Similarly, the μ-meson results indicate that the attenuation factor is again dependent upon shower size, and as for the nucleons, the μ-mesons are less attenuated in small showers than in large.

It may be unwise, however, to carry too far an argument which assumes that a given shower size at sea-level may be related uniquely to a corresponding shower size at mountain altitude, and that this in turn may be related uniquely to a corresponding energy of the primary particle. Fluctuations in the development of the air shower, together with the existence of a spectrum of energies and of masses of the air-shower primaries, may modify considerably the interpretation of the experimental data.

A further point of comparison between the mountain and the sea-level results is afforded by the forms of the distribution functions for μ-mesons and for nucleons which have been determined at the two altitudes. It has already been noted by the Harwell group that the Pamirs μ-meson distribution falls off more rapidly at large distances than does theirs. On the other hand, the structure function which we have used as a good fit to our sea-level results for nucleons may be also fitted to the experimental points for two shower sizes quoted by Vavilov *et al.* Their nucleons were detected in a similar apparatus and were selected according to the same criterion as our own. There is consequently no indication that the nucleons are spread out more at sea-level than at mountain altitude.

Lastly, the results have been compared with the theoretical predictions of Ueda and Ogita[3]. Those authors calculated the longitudinal development of a model air shower initiated by a primary particle of energy 10^{15} eV. and derived as a function of depth in the atmosphere the total numbers of electrons, μ-mesons and nucleons for different values of the inelasticity, η, of the nucleon–nucleus collisions. Table 1 gives the theoretical predictions of the total numbers of electrons, of nucleons of energies greater than 10 GeV. and of μ-mesons produced by decaying π-mesons above the same energy-limit, for different values of η. Also given are the estimates of these numbers from the experimental observations. The nucleon numbers at sea-level are those obtained by integrating our analytical expression for $f(r)$. The numbers of nucleons at mountain altitude are obtained by increasing the values quoted by Vavilov *et al.* by 30 per cent, to include a contribution from nucleons at distances greater than 50 m. The total numbers of μ-mesons have not been calculated since the contribution from large distances where the structure function is not well defined is considerable; instead we have quoted a number proportional to the density of μ-mesons at a distance of 20 m. from the core of the shower, neglecting the fact that the μ-meson distribution at mountain altitude appears to be narrower than at sea-level. If, in fact, both at sea-level and at mountain altitude, the nucleons detected in the experiments are of energy greater than 10 GeV. and the μ-mesons detected are proportional to the number which have come from π-mesons of energy greater than 10 GeV., the data are seen to be in reasonable agreement with theoretical expectation for $\eta = 0{\cdot}3$. Again, however, it should be pointed out that this one-to-one correlation between primary energy and detected shower size at two altitudes may be of doubtful validity.

Summary

We have determined the nucleon and μ-meson density distribution for showers of size 5×10^4 to 2×10^6 scintillator particles out to distances of 40 m. from the shower core. There is no significant evidence that the forms of the distribution functions change with shower size, although additional statistics will be required in order to determine whether this is really the case.

On the assumption of a constant form for the radial structure function, the number of μ-mesons in the showers recorded varies as $N^{0{\cdot}4 \pm 0{\cdot}1}$ and of nucleons, as $N^{0{\cdot}6 \pm 0{\cdot}1}$, within the range of shower sizes investigated. Comparison with similar experimental observations at mountain altitude indicates, on this assumption, that the attenuation-length of nucleons and of μ-mesons is longer in small showers than in large.

A comparison has been made with the theoretical results of Ueda and Ogita for one primary of energy 10^{15} eV. and this leads to agreement with a value of 0·3 for the inelasticity of the high-energy collisions of the nucleon cascade. An extension of the theoretical calculations, in the first instance to cover a range of the primary energy spectrum, and to include the effects of fluctuations in depth of the first collision, would probably allow a more detailed and a more meaningful comparison to be made with all the experimental data which are at present available.

Our thanks are due to Prof. H. Messel and to the Nuclear Research Foundation for the provision of the experimental facilities with which this work was carried out. It is a pleasure to acknowledge the large part played by the other members of the Air Shower Group in running the experiment and in discussion of the results. One of us (J. A. L.) has been

supported in this work by a grant from the Australian Atomic Energy Commission.

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NUTRITION AND TEETH

THE Nutrition Society symposium on the relationships between nutrition and the growth and health of teeth was held at the London Hospital Medical College on October 4, when the chair was taken by Lady Mellanby. The meeting opened with a general review by Prof. F. C. Wilkinson.

The structure of teeth was dealt with by Prof. A. I. Darling, and their embryology, with particular reference to the histochemistry, by Dr. R. Ten Cate. The tooth consists largely of dentine, the material which gives it its elasticity. Whereas root dentine is covered by a thin layer of cementum, crown dentine is covered by enamel. At the centre is a cavity containing the dental pulp. The tooth is slung in its sockets by the fibres of the periodontal membrane which stretch from the bone of the alveolus to the cementum, and at its neck is an attachment between the oral mucosa and the enamel which is itself of ectodermal origin. Chemically, dentine contains about 5 per cent water, 75 per cent other inorganic constituents, mainly hydroxyapatite, and 20 per cent organic constituents[1], mainly collagen, but with small amounts of citric acid, insoluble protein, mucopolysaccharides and fat. Structurally, it is composed of a collagenous matrix which, when calcified, forms its main bulk, through which run the dentinal tubules from the pulp to the amelodentinal junction.

As the tooth develops, a series of changes occur which eventually determine the pattern of the crown, after which the dentine and enamel are elaborated. The formative cells of the dentine, the odontoblasts, are rich in carbohydrate and nucleic acid. Their precise function remains obscure, but close by is the sub-odontoblastic layer rich in alkaline phosphatase activity and with a high content of ribonucleic acid, which probably indicates protein metabolism[2]. The dentine matrix consists of a cementing substance and the so-called fibres of von Korff, which arise in the sub-odontoblastic layer and which gradually change from pre-collagen to collagen. As the matrix becomes calcified the odontoblasts retreat, leaving behind the processes which become incorporated in the tubules running through the dentine. With ageing of the tooth, these tubules close down and are eventually obliterated, perhaps by calcification within the tubule.

Mature dental enamel, consisting of approximately 0·5 per cent of organic material and 99·5 per cent of inorganic salts and water[3], is the hardest tissue in the body—about as hard as sapphire. The process of amelogenesis consists in the formation of an enamel matrix and in the calcification of the enamel. The enamel-forming cells, the ameloblasts, produce at their formative ends Tomes processes which become the pre-enamel rods into which calcium salts are precipitated. Initially, ameloblasts are rich in glycogen, which disappears as the Tomes processes are elaborated. This may represent a phosphorolytic degradation of glycogen to hexosephosphate esters utilized in the synthesis of acid mucopolysaccharide of the enamel matrix. In amelogenesis, as in dentinogenesis, the formative cells are devoid of alkaline phosphatase and yet exist close to cells rich in the enzyme where, it can be postulated, the mucopolysaccharide is made[4]. This has the property of imbibing water, and probably plays an integral part in forming the crown. Calcification starts soon after the deposition of the matrix, which consists mainly of keratin but contains some soluble protein and carbohydrate, and is probably not completed until shortly before eruption. Enamel is made up of prisms arranged in a complex manner. Soluble organic material lies between them and at their cores, while the prism sheaths are keratinous. The inorganic part of the enamel is almost certainly a hydroxyapatite, with some carbonate adsorbed on to the surface of the lattice, and trace elements such as fluorine, copper and iron actually within or also adsorbed on to the surface of the lattice. The trace elements occur almost exclusively in the surface enamel.

Cementum is very like bone, and consists of a collagenous matrix in which calcium salts are deposited. The dental pulp is the remnant of the organ forming dentine and consists mainly of connective tissue cells with a layer of odontoblasts next to the dentine. It communicates with the periodontal membrane, from which it receives its nervous, vascular and lymphatic supply. Nerve fibrils reach the pulp in large numbers and branch beneath the odontoblastic layer. From there, nerve fibrils pass into the uncalcified layer of pre-dentine and probably into the dentine[5], but not the enamel. The vascular and lymphatic supply is rich and closely related to the supply to the periodontal membrane. It seems that there are pathways from the pulp to the oral surface and to the periodontal membrane and *vice versa*, but how they are used in life for the purposes of exchange is still unknown. Exchange in dentine is probably much less than in bone, and enamel is more stable still. When enamel is impermeable the barrier is probably at the enamel surface. The precise role of nutritional factors in the formation of the different parts of teeth has not been elucidated, but it seems that if such factors are to affect the

resistance of enamel to attack they must act during the formative period.

Dr. E. W. Bradford stressed that far more teeth are lost by the periodontal diseases, which affect the gum, the alveolar bone, the periodontal membrane and the cementum, than by dental caries. These are of three groups: inflammation of the gums or gingivitis; periodontitis simplex or destruction of the supporting tissues by bacteria or tartar; periodontitis complex or destruction of the tissues for no local reason. They can be considered as a battle between the invasiveness of bacteria and the accumulation of tartar, and the resistance of the periodontal tissues. The result varies greatly between individuals, for reasons almost unknown. The effect of food can be local or systemic. Locally, a high carbohydrate diet stimulates the secretion of saliva with a high water-content and rich in inorganic salts which can form tartar. The proportion of tartar which accumulates on the teeth varies with the amount of chewing, which at all ages promotes the health of the teeth. Thus the more fibrous the diet the better. Much less is known about the systemic effect of diet. In gingivitis and periodontitis simplex, dietary deficiencies are rarely the primary cause. Deficiency of vitamin C or of vitamin D and calcium can be contributory, though probably not causative, in periodontitis complex. Shortage of one or another essential amino-acid in the supporting tissue might be the decisive deficiency and is ripe for investigation.

Dental caries is the result of bacterial attack on the surface of the tooth: the point of interest is what starts the attack. Dr. R. L. Hartles and Mr. G. L. Slack described the incidence, since the beginning of the Second World War, of dental caries in Britain[6] and other countries[7], and gave as the most likely explanation of reduced incidence in war-time the reduced consumption of fermentable carbohydrate. They discussed the results of experiments on rats[8], hamsters[8] and monkeys[9] with natural and high-sugar purified diets, which suggest that such a purified diet is cariogenic and more so if fed during the development of teeth, but that the natural diet fed during development bestows some protection, probably in its mineral fraction, against subsequent exposure to the purified diet.

Dr. G. N. Jenkins also described experiments which suggest the presence of protective factors, possibly buffers, calcium and phytates in crude cane juice, black treacle and high-extraction flours. There was general agreement that the only factor which has been proved to be of value in reducing the incidence of caries in man is the fluoride ion, which makes the enamel more resistant to dissolution by acids: it may act as an enzyme poison preventing the formation of acids. Dr. Jenkins mentioned the possibility that the initial attack on enamel might be made by proteolytic bacteria and might result in decalcification at neutral or alkaline *p*H, but based his review of the environmental aspects of dental caries on the idea that the acids formed from carbohydrate by oral bacteria are the major factor in the development of caries. He described experiments[10] which lead to the conclusion that carbohydrate causes the *p*H of the dental 'plaque' to fall from 7·0 to about 5·0, and that at a critical point, varying with individuals but somewhere between 5·5 and 5·0, the ionic concentrations of the saliva are no longer able to prevent dissolution of the enamel. The more rapid the flow of saliva, the higher the *p*H and buffering power[11]. Thus, tough foods and vigorous chewing help to prevent the saliva reaching the critical *p*H; frequent carbohydrate meals[12] help to bring it there.

The general impression that sufficient protein, mineral and vitamin constituents are necessary for the formation of sound teeth, but that their health can be lost by much soft carbohydrate and insufficient chewing found some support in an archæological review by Mr. D. R. Brothwell. He took the meeting back half a million years to show that signs of dental disease had been found even among early hominid groups[13], and 15,000 years ago among Neanderthal man[14]. His conclusions were that the incidence of dental disease was low in neolithic times when teeth may have been helped by the rough nature of the food consumed, that, in general, dental health declined thereafter, and that for the population of the British Isles the causative factors were the introduction of sugar in the twelfth century and refined flour in the nineteenth. It is clear, however, that even without these adjuncts of civilization neither man nor ape was immune from dental disease.

A combined attack of dentist and dietitian on gross caries in young children was described by Mr. A. M. Horsnell and Mrs. E. Scott. While carious primary teeth can be filled, for treatment to be satisfactory the carious process must first be stopped. This has been achieved by giving dietary advice based on an assessment of the nutritional value of the diets of the patients. Dietary results showed a fairly consistent pattern of snacks between meals, low intakes of protein, calcium, and sometimes iron and some vitamins, and high consumption of carbohydrate. The advice given was to emphasize the importance of milk, vegetables and fruit, such as a raw apple, and a good breakfast containing a source of protein (to avoid the tendency for a mid-morning carbohydrate snack); that no snacks should be taken between meals and that any sweets should be eaten with meals. Dental and general health of the children can be improved when the co-operation of parents and children has been won. To the audience, somewhat bemused by the complexities of the biochemistry of dental development and destruction, this clear demonstration of the effectiveness of the most promising regimen for the protection of teeth was a joy.

The papers read at the symposium will be published in full in the first issue of Vol. 18 of the *Proceedings of the Nutrition Society*, which will appear in March 1959.

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OBITUARIES

Sir Gilbert Walker, C.S.I., F.R.S.

Sir Gilbert Walker died on November 4, some four months after his ninetieth birthday. For half a century his has been a prominent name in meteorological circles, and in recent years one was apt to forget that he had been elected a Fellow of the Royal Society for original work in dynamics and electromagnetism before ever he turned his thoughts to meteorology.

Walker went up to Trinity College, Cambridge, from St. Paul's School with a mathematical scholarship. He fully confirmed his early promise on graduating as the Senior Wrangler in the Mathematical Tripos of 1889, an achievement that was followed in due course by election to a fellowship of Trinity and then to a lectureship, both of which he held until going to India. From 1892 onwards he published a series of papers on the theory of electromagnetism, for one of which he was awarded an Adams Prize in 1900. In the same period he was showing a keen interest in dynamical problems, with papers on such subjects as the motion of elongated projectiles, dynamical tops and boomerangs, in which his interests were not wholly theoretical, for he became expert as designer and thrower of boomerangs, and indeed was known in the Cambridge of those days as 'Boomerang Walker'. It is a matter for some regret that his article on "Spiel und Sport" in the great "Encyklopädie der Mathematischer Wissenschaften" was never well known to his own compatriots.

Walker went to India in 1903 to succeed Sir John Eliot as director-general of observatories. The great Indian famine of 1899–1900 was still very much in people's minds and, as it were, challenged Walker to attempt to solve the very complex and difficult problem of forecasting the monsoon rainfall. The physical causes that produce the fluctuations from year to year defied and still defy detection. Walker decided to apply the statistical methods of correlation and soon made the subject of seasonal 'foreshadowing' by these methods peculiarly his own. His investigations, beginning with the search for relationships between previous weather over different parts of the globe and the Indian monsoon rainfall, developed into an examination of the interrelations of world-wide variations of weather, contemporary and consecutive. His papers are a mine of statistical information on world weather, interspersed with concise, critical and acute comment. Of the more important generalizations that emerged, there was one that he called the Southern Oscillation, which may be described as a tendency for air to disperse from the Pacific area at the same time as air accumulates in and around the Indian Ocean. The monsoon plays a part in the Southern Oscillation, out of the elements of which he evolved a formula for 'foreshadowing' monsoon rainfall, which has continued in use in India with but little amendment. Walker would not claim to have solved the monsoon problem, but he pointed a way, and the value of these papers can scarcely be overestimated.

Living in the Simla hills, Walker was fascinated by the soaring flight of birds, at first as a hobby, then as a study on which he wrote several papers, including the article in the "Encyclopædia Britannica" on animal flight.

After retiring from India in 1924, Walker succeeded Sir Napier Shaw as professor of meteorology at the Imperial College of Science and Technology, London. One of the subjects to which he turned his own and his pupils' attention was the cellular structure of an unstable fluid. In striking laboratory experiments they obtained a variety of cellular forms—polygons, transverse and longitudinal vortices—by varying the rate of shear in the fluid, and they were able to show that this physical process explained the mode of formation of a wide variety of cloud forms.

Walker lived in Cambridge from 1934 until after the Second World War, officially retired but continuing to write papers on meteorological subjects. During the War he acted, in effect, as an honorary consultant on problems of long-range forecasting.

Walker was a man of wide interests, a highly proficient skater and climber in his younger days, always very fond of music, happy to spend a day out of doors sketching in water colour, ever eminently reasonable, liberal minded and very friendly. In all his posts he demonstrated his great intellectual capacity and served with distinction, deservedly reaping many honours during his long life.

Charles Normand

Mr. Stephen Butterworth, O.B.E.

Stephen Butterworth died on October 28 at the age of seventy-three at his home in Cowes, Isle of Wight, having retired from the Admiralty scientific staff in 1945.

After being educated at the University of Manchester, Butterworth was for eleven years a lecturer in physics at the Manchester Municipal College of Technology. Afterwards he worked for a few years on electrical standards at the National Physical Laboratory before joining the Admiralty Research Laboratory in 1921, where he remained for twenty-four years until his retirement.

Butterworth was a first-rate mathematician who possessed the rare ability to apply his mathematics successfully to a wide variety of practical problems. Before his Admiralty period he was mainly concerned with electrical investigations such as the theoretical determination of standards of inductance and accurate methods of measurement. This work, unlike much of what he did later, was fully published in the scientific Press, and his theoretical formulæ for inductances and the high-frequency resistance of coils have been extensively quoted and used.

His achievements with the Admiralty are too numerous to mention in detail, but the following indicate the diversity of his activities. In his early days he studied the possibilities of ship navigation by the use of a 'leader cable'; and, by solving the complicated electromagnetic field surrounding a submarine cable carrying alternating current, he was able to provide a complete theoretical background for all subsequent design work. He concerned himself with underwater weapons and made valuable contributions to our understanding of the stability of torpedoes

which led to significant improvements in design. At another period he gave his attention to underwater explosion phenomena and among other things predicted the multiple oscillations of the explosion gas bubble, an effect that was observed experimentally many years later. In the early part of the Second World War he was much involved with the problem of the magnetic mine and made big contributions to the successful degaussing of our ships.

Butterworth possessed the ability to apply his mathematics to problems which at first sight appeared unlikely to admit of mathematical solution. He was, however, able to make progress in many cases by introducing judicious approximations to the physical conditions. Naturally, much depends on knowing the right approximations to make, and in this respect Butterworth invariably displayed an unerring understanding of the physical realities of the situation. He also showed ingenuity in devising experiments both to test his theories and to make progress with problems too complex for mathematical treatment. Naval science is often concerned with large-scale effects, where systematic and extensive experimentation is very difficult. In such cases he would aim at devising a model which could be studied exhaustively in the laboratory. He was able to show, for example, that the complicated details of magnetization of a ship's structure under the combined influence of its degaussing coils and the magnetic field of the Earth could be accurately reproduced using an appropriately scaled steel model of the ship. This made possible an enormous saving of effort when degaussing specifications had to be worked out for a variety of ships during the Second World War. In the same way, he was able to study the trajectories and the effects on entering the water of underwater projectiles by means of small models in a laboratory tank, thus reducing the need for difficult and expensive full-scale experiments at sea. In this case the technique which he developed at Teddington many years ago has been followed by other laboratories ever since.

For security reasons it was impossible for Butterworth to publish much of his work, and on this account his general recognition in the scientific world has been much less than it would otherwise have been.

Although one of the most outstanding scientists in the Admiralty's service, Butterworth was a very quiet and unassuming man. His expert advice was sought on all sides, and he was always ready to give it. His colleagues throughout the Admiralty scientific service had deep respect for him, and those young men fortunate enough to work under his direction held him almost in veneration. H. F. WILLIS

NEWS and VIEWS

The Queen's University, Belfast : Prof. Michael Grant, C.B.E.

PROF. MICHAEL GRANT, who holds the chair of humanity in the University of Edinburgh, has been elected president and vice-chancellor of The Queen's University, Belfast. He will succeed Sir Eric Ashby (who takes up residence as master of Clare College, Cambridge, next July) in August 1959. Prof. Grant brings a wealth of experience to his new office. He was educated at Harrow and Trinity College, Cambridge. In 1938 he was elected into a Fellowship at Trinity. During the War he was seconded from the Army as British Council representative in Turkey and he later became deputy director of the European Division of the British Council. In 1948 he was appointed professor of humanity in the University of Edinburgh, and during 1956–58 he had leave of absence from his chair to serve as first vice-chancellor of the University of Khartoum. He filled the office of vice-chancellor at Khartoum with distinction through a period of great political and constitutional unrest. Prof. Grant goes to The Queen's University at a time when it is developing rapidly. He will have the double responsibility of maintaining the University's international status and at the same time preserving the University's close ties with its region. He has high qualifications for this double responsibility, and it is a cause of great satisfaction that university education in Ulster will be under such experienced leadership.

Department of Leather Industries, University of Leeds : Prof. D. Burton

IT has been announced that Prof. D. Burton is to retire in September 1959 from the chair of leather industries in the University of Leeds, which he has held since 1951. Since 1955 he has also been director of the Procter International Research Laboratory, where he was at one time the first research assistant. During his tenure of office there has been a considerable expansion of the activities of his Department. The courses have been revised and the research facilities greatly extended ; an electron microscope has been installed and put to good use ; the experimental tannery has been modernized and re-equipped ; a laboratory for microscopy and bacteriology has been opened ; and the Atkin–Thompson postgraduate research laboratory added. Among the topics studied has been the nature and material of the Dead Sea Scrolls. Prof. Burton is widely known and respected in the leather industry as well as in academic circles, and a large number of friends will wish him well in his retirement.

Prof. A. G. Ward

MR. A. G. WARD has been appointed to succeed Prof. Burton. After obtaining first-class honours in physics at Cambridge and working, for a time, in the Department of Colloid Science in that University, Mr. Ward was lecturer in physics and mathematics at the Technical College at Stoke-on-Trent, until the Second World War, when he worked with the Armament Research Department. During 1946–49 he was in charge of research on rheology at the Building Research Station, after which he became the first director of the British Gelatine and Glue Research Association. Apart from his duties as director, Mr. Ward has made notable advances in our knowledge of the properties of gelatine. His authoritative article (with P. R. Saunders) in the recently published second volume of F. R. Eirich's "Rheology : Theory and Applications" is of outstanding merit. Though Mr. Ward's interests cover a wide field of colloid science, and his little book on colloids, published in 1945, has been much praised, he is perhaps

best known as a rheologist. He was president of the British Society of Rheology during 1951–53, his term of office including the Second International Congress on Rheology held at Oxford. As president, he also served as chairman of the organizing committee of this Congress, in which capacity his administrative abilities and keen business acumen were greatly appreciated.

Molecular Biology in the University of Oregon : Dr. A. Novick

Dr. Aaron Novick, who has been on the staff of the University of Chicago for eleven years, has recently been appointed director of the Institute of Molecular Biology at the University of Oregon. He graduated in chemistry in 1940 and received the degree of Ph.D. in 1943, both in the University of Chicago. Dr. Novick's research has been principally in the genetics and physiology of micro-organisms, reaction kinetics, nuclear measurements and radiation chemistry. During 1943–47 Dr. Novick was with the Manhattan District Project, when he worked in the fields of radiation chemistry, radiochemistry and nuclear physics. In 1947 he was made a research associate with the rank of assistant professor in the Institute of Radiobiology and Biophysics of the University of Chicago. He worked as a Guggenheim Fellow at the Pasteur Institute in Paris during the year 1953–54 before returning to Chicago as associate professor.

European Organization for Nuclear Research

The Council of the European Organization for Nuclear Research (CERN) recently approved contributions from the twelve member States totalling 55,000,000 Swiss francs for 1959 (compared with a budget of 56,000,000 Swiss francs for 1958). Good progress was made during 1958 in the construction of the Organization's two big particle accelerators and of other buildings and ancillary facilities. The first machine, a 600-MeV. synchrocyclotron, came into operation on August 1, 1957. It was recently used to demonstrate, for the first time, the two modes of decay of π-mesons—an experiment of critical importance to fundamental nuclear theory. In view of the rapid progress made at the CERN building-site during 1958, the second accelerator, the 25-GeV. proton-synchrotron, will probably be finished in 1960, the target date originally set. It will then be the biggest particle-accelerator in existence.

Prof. P. Scherrer (Switzerland) and Dr. G. Funke (Sweden) were elected as new members of the Committee of Council. Sir Harry Melville, secretary of the Department of Scientific and Industrial Research of the United Kingdom, was re-elected as member of the Committee. The following were also re-elected : M. F. de Rose (France) as president of the Council ; Prof. W. Heisenberg (German Federal Republic) and M. J. Willems (Belgium) as vice-presidents of the Council ; M. J. H. Bannier (Netherlands) as chairman of the Finance Committee ; Prof. E. Amaldi (Italy) as chairman of the Scientific Policy Committee ; and Prof. W. Heisenberg (German Federal Republic) and Prof. H. Alfvén (Sweden) as members of the Scientific Policy Committee.

Calder Hall Completed

All the reactors at the two Calder Hall nuclear power stations are now working. This stage was reached during the night of December 8–9 when the fourth reactor on the site went critical. The operation was successful and this reactor will now undergo a series of tests while working up to full power in preparation for linking with the grid system to provide electricity. There are two atomic stations at Calder Hall, known as 'A' and 'B'. Work on the first of these started in the summer of 1953 and on the second in 1955. Each station has two reactors and the first of the two in Calder 'A' started operating in May 1956. It achieved full power and was switched into the grid on October 17, 1956, by Her Majesty the Queen. It thus became the first atomic power station in the world to produce electricity on a commercial scale. Both the reactors on the first station have been successfully supplying electricity to the national grid system since February 1957. The power capacity of the four turbo-generators associated with the two reactors is 92 megawatts, of which about 70 megawatts is used by the grid. So far just over 750 million kilowatt hours have been supplied. The first reactor of Calder Hall 'B' started operating in March this year and has been running successfully. Delivery of power was delayed by an accident to a turbo-generator in June, but will probably take place before the end of the year. The last reactor to start operating will start production of electricity two or three months later. The two stations together will have a capacity of 184 megawatts and will supply 140 megawatts to the national grid. A similar station with four reactors is now nearing completion at Chapelcross, near Annan in Dumfriesshire. One of the reactors here is already operating and the whole station will be complete by the end of next year.

Import Duty on Scientific Apparatus and Instruments

In a written Parliamentary reply on December 10, Sir David Eccles, president of the Board of Trade, stated that arrangements are being made for widening the scope of the arrangements for remitting duty on optical and scientific apparatus and instruments. The Board will be prepared to consider such apparatus and instruments imported on and after January 1, which satisfy the definition in the Import Duties Act, 1958, where the rate of duty is 25 per cent or more (minimum chargeable, £50). The President set out a list of apparatus and instruments which will be so considered, provided that they are not obtainable, for the time being, in the United Kingdom.

Josiah Wedgwood and Research

Commenting on the paragraph under this heading in *Nature* of October 25, p. 1130, Dr. A. T. Green, director of research of the British Ceramic Research Association, writes : "This is a striking example of his remarkable foresight, but I should like to point out that the letters between Wedgwood and Bentley, describing the former's efforts to persuade his fellow potters to co-operate in this venture, were rather fully extracted some 28 years ago in the "Wedgwood Bicentenary Volume" of the British Ceramic Society. The fact that Wedgwood, in 1775, proposed the formation of what might have been the first research association, has frequently been mentioned and is a matter of some pride to those of us engaged in ceramic research at the present time".

Northern Advisory Council for Further Education

The eleventh annual report of the Northern Advisory Council for Further Education, which

covers the year ended March 31, 1958, records the decision of the Minister of Education to develop the Rutherford College of Technology into a college of advanced technology (see *Nature*, **179**, 1277; 1957), and the Committee of Chief Education Officers has already submitted recommendations on advanced courses. Among the new buildings noted in this report are the second instalment of Carlisle Technical College, to be ready for occupation for the session 1959–60; completion of the first phase of additions to the Workington College of Further Education; full completion of the Joint Stockton/Billingham Technical College; completion of the first instalment of the Durham Technical College and the Bishop Auckland Technical College; commencement of the third stage of the new Rutherford College of Technology; and the coming into use of the first instalment of Easington Technical College; the first instalments of the County Technical College, Ashington, and the South Shields Marine and Technical College; and of major extensions to the Sunderland College of Art. After a general review of the Willis Jackson report on the "Supply and Training of Teachers for Technical Colleges", the programme committee recommended that the Advisory Council should take appropriate steps to implement the recommendation that industry should be more fully acquainted with the staffing problems of colleges; that through the programme committee it should prepare a comprehensive programme of part-time courses of training for technical teachers, and that a proper service of organizing tutors should be established. The first series of short initial training courses for new teachers in technical colleges was held at Middlesbrough, Newcastle and Workington.

The International Institute for the Conservation of Museum Objects

THE International Institute for the Conservation of Museum Objects was founded to provide a permanent organization to co-ordinate and improve the knowledge, methods and working standards needed to protect and preserve precious material of all kinds. Dissemination of information on research into and development of all processes connected with conservation, both scientific and technical, is an essential part of its function. A substantial grant from the Gulbenkian Foundation, covering the next three years, has recently been received by the Institute. Since 1950 the Institute has expanded continuously, until now it has members in more than thirty countries and in most major museums of the world. It has published its journal, *Studies in Conservation*, which carries out the Institute's policy of disseminating information, since October 1952 (hitherto published twice yearly, but quarterly beginning 1959), and *Abstracts of the Technical Literature on Archaeology and the Fine Arts* since 1955. Members are kept in touch with each other by means of the *News Letter*, which also carries items of special interest, and which has been published by the American Office of the Institute since 1952. One of the most important functions of the Institute is to be able to put members in touch with the appropriate experts in any particular field of conservation. This is a service which is constantly expanding, and although up to the present time it has been available to members only, it is hoped to be able to extend the service to the general public in 1959. The Institute, while not possessing a laboratory of its own, is in touch with all institutions which specialize in technical research and development relating to the care of artistic patrimony, and has become one of the internationally recognized channels for the communication of their results.

In order to increase the international character of the Institute, the former Management Committee retired in January 1958, and was replaced by a ten-member Council, representing approximately the present topographical distribution of members of the Institute. Its members are: *President*, W. G. Constable; *Vice-Presidents*, Dr. P. B. Coremans, Dr. H. J. Plenderleith, F. I. G. Rawlins; *Secretary-General*, N. S. Brommelle; *Treasurer*, S. Rees Jones; *Ordinary Members of Council*, R. J. Gettens, Dr. S. Paramasivan, Dr. A. van Schendel, G. L. Stout; *Membership Committee*, Dr. Paul Coremans, Sheldon Keck, Dr. Arthur van Schendel, Mme. Magdeleine Hours, the Secretary-General (*ex-officio*). Information concerning the Institute can be obtained from the assistant secretary, Miss R. M. Spielman, c/o The National Gallery, Trafalgar Square, London, W.C.2.

Electric Technology, U.S.S.R.

THE increasing importance of Russian scientific and technical literature is reflected in the appearance of journals comprising selected papers and articles translated from the Russian. A recent addition to this series is *Electric Technology, U.S.S.R.* (four volumes comprising approximately 700 pages per annum. Annual subscription £20 (56 dollars); single volumes £6 (17 dollars). London and New York: Pergamon Press, 1958), containing translations of articles from *Elektrichestvo*, the leading Russian journal dealing with heavy-current electrical engineering and, incidentally, one of the oldest electrical journals in the world. It is proposed to publish in the new journal only those articles from *Elektrichestvo* having the greatest general interest and value. The publishers state, however, that they will be able to provide a translation of any article which has appeared in the Russian journal. The contents of the first issue represent papers selected from *Elektrichestvo*, Nos. 1–4, 1957, and cover a wide range of topics, including, for example, short-circuit transients on long lines, the problem of impulse tests on the turn insulation of a high-voltage machine, the use of amplidyne and transistor amplifiers in industrial drives, the measurement of earth resistances and the stabilities of measuring instruments using 'Magnico' and 'Alnico'.

While it is no doubt true that the existing abstracting, translating and reprint services cover the field of Russian scientific literature very satisfactorily and provide the scientist and engineer with copies of specific papers which he may wish to consult, there does appear to be a useful purpose to be served by a journal which selects, translates and publishes at intervals the most important Russian articles in a given field. Such a publication enables the reader not only to form some picture of the range of work being done in his field but also to read, from time to time, an important paper in full, without requiring to take special steps to obtain it in translation. *Electric Technology, U.S.S.R.*, is a welcome addition to the literature of electrical engineering.

International Glossary of Wood Anatomy

IT is very satisfactory to find that action is being taken in several scientific fields to secure agreement

on the precise meaning of the many special terms that have come into use among research workers and others. Relatively few such terms have been deliberately invented and defined on introduction into the literature, and even of these a large proportion tend, with time, to be loosely used, sometimes with a meaning very different from what was originally intended. In this way, ambiguity creeps in, causing confusion until action is taken to secure standardization, or at least definition, and indication of preferred usage. Among the groups to take action of this kind is the International Association of Wood Anatomists which, realizing the need for revision of the glossary produced in 1933, has recently published a new glossary of more than two hundred terms with definitions (*Tropical Woods*, No. 107; October 1957: International Glossary of Terms used in Wood Anatomy. Pp. 36. Zurich: International Association of Wood Anatomists, Universitätstrasse 2; New Haven, Conn.: Prof. William L. Stern, 205 Prospect Street, 1957). By a fortunate coincidence, the second part of a British Commonwealth Forest Terminology was under compilation at the same time and agreement has been secured for all the terms included in both. Furthermore, it has been agreed that these English glossaries, co-ordinated so far as possible with the American equivalents, are to form the basis of multi-lingual glossaries for international usage. This is an important step in the right direction.

Gairdner Foundation Awards in Arthritis and Heart Disease

The Gairdner Foundation has announced its first international awards in arthritis and heart disease, totalling 40,000 dollars. Medical scientists from Britain, the United States and Canada are included among the seven recipients. The Gairdner Foundation Award of Merit of 25,000 dollars has been awarded jointly to Dr. Alfred Blalock and Dr. Helen B. Taussig (Johns Hopkins University, Baltimore) for their initial development of what is popularly known as the 'blue-baby operation' for congenital obstruction of the pulmonary artery. Three annual awards of 5,000 dollars each have been awarded to the following: Profs. H. M. Rose and C. Ragan (Columbia University, New York) for their discovery of an agglutinating reaction affording the first practical laboratory blood-test for the diagnosis of rheumatoid arthritis; to Prof. W. D. M. Paton (Royal College of Surgeons of England) and Prof. Eleanor Zaimis (Royal Free Hospital School of Medicine, London) for their discovery of the methonium compounds, the first drugs effective in the treatment of high blood pressure; to Dr. W. G. Bigelow (University of Toronto) for his development of the technique of hypothermia for heart surgery.

Christmas Lectures at the Science Museum

Christmas lectures for children aged thirteen to seventeen years are to be given for the first time this year at the Science Museum. There will be two subjects: first, "From Man Power to Atomic Power" on December 31, repeated on January 1 and 2; second, "The Story of Flight" on January 5, repeated on January 6 and 7. The lectures will be illustrated by many demonstrations and the young audiences will be able to see such things as a Montgolfier hot-air balloon rising to the ceiling of the lecture theatre and a noisy and spectacular 'mock-up' of a gas turbine. The lectures will commence at 2.30 p.m. and admission is free and without ticket.

Science Museum Exhibition on Controlled Nuclear Fusion

A small exhibition at the Science Museum, South Kensington, open from December 18 until the end of March 1959, illustrates British research in the field of controlled nuclear fusion. The centre-piece of the exhibition is a one-third scale model of Zeta, the apparatus developed at Harwell. This model was shown in the exhibition held at Geneva last September in connexion with the Second International Conference on the Peaceful Uses of Atomic Energy, and simulates the flashing discharge which in Zeta produces fusion of atoms. Another scale model, which was on view for six months at the Brussels World Fair, shows the apparatus known as Sceptre III, which was made by Associated Electrical Industries, Ltd., and gives results similar to those obtained with Zeta. Examples are also shown of pioneer apparatus used at the beginning of this type of work twelve years ago.

Announcements

The Agricultural University of Wageningen is organizing an international conference on "Enzymes and their Action", to be held at Wageningen during April 6–10. Further information can be obtained from Dr. H. Veldkamp, Laboratorium voor Microbiologie, Hesselink van Suchtelenweg 4, Wageningen, The Netherlands.

An international conference on "Co-ordination Chemistry", under the sponsorship of the International Union of Pure and Applied Chemistry, will be held in London during April 6–11. The conference is being organized by the Chemical Society, and further information can be obtained from the Secretary, International Conference on Co-ordination Chemistry, Chemical Society, Burlington House, London, W.1.

A symposium on "The Biology of Weeds" is being arranged by the British Ecological Society, to be held in Oxford during April 2–4. The programme will include papers on the ecology, systematics and physiology of weeds, the origin and development of weed floras, competition and population studies in weeds, and dormancy characteristics of weed species. Limited accommodation will be provided in Brasenose College. Inquiries should be addressed to Dr. J. L. Harper, Department of Agriculture, University of Oxford.

The Institute of Physics is arranging a conference on "Some Aspects of Magnetism", to be held in Sheffield during September 22–24, 1959. The subjects to be covered by the conference are: (*a*) fundamental theories of ferro-, ferri- and antiferro-magnetism, including magnetic structure; (*b*) theories of technical magnetization processes, including hysteresis, coercivity, anisotropy and directional effects; (*c*) domain phenomena in bulk materials and thin films; (*d*) antiferromagnetism in metals and non-metals. Each session will be opened by an invited speaker, and other contributions should be submitted to the Conference Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1, before January 31. Abstracts (but not preprints) will be circulated before the conference, the proceedings of which will not be published in full.

REORGANIZATION OF THE METEOROLOGICAL OFFICE

IN 1955 a small committee with Lord Brabazon as chairman was appointed by the Secretary of State for Air to review the organization of the Meteorological Office. The quite radical changes that followed the investigations and recommendations of the Brabazon Committee took effect on July 1, 1957, and their nature is described in the annual report of the Meteorological Office*.

It was as a department of the Board of Trade, serving the interests of shipping, that the Meteorological Service began its existence in 1855, and it assumed the name by which it is now known when it was later transferred to the control of a committee nominated by the Royal Society. The Office retained its autonomy as a separate Government department through several succeeding reorganizations, until, in 1919, the War Cabinet decreed that it should absorb the three separate meteorological units which had been established to serve the needs of the Royal Navy, the Army and the Royal Air Force, and that it should henceforth become attached to the department making the greatest use of its services, the Air Ministry. A Meteorological Committee composed of representatives of its principal customers, of the Royal Societies of London and Edinburgh, and of the universities, was set up to act as a board of management.

During the period between the two World Wars, the comparatively small scientific staff was, in the main, fully occupied in operational forecasting, which inevitably involved liability for work at irregular hours and frequent transfers between stations at home and abroad, many in isolated situations. Less-favourable conditions for research can scarcely be imagined, yet some members of the staff successfully undertook investigations of fundamental importance, mostly in their leisure hours.

During the Second World War, the director, the late Sir Nelson Johnson, instigated two important developments with the aim of furthering the progress of research within the Office. The Meteorological Research Committee, composed of senior scientists from within the service and from the universities, was established in 1941 with the object of providing advice on the general planning of the programme of research. During the next year the Meteorological Research Flight was set up at Farnborough and has now behind it a substantial achievement that has earned an international reputation.

It was probably the difficulty experienced after the War in securing adequate staff with the necessary qualifications that was the principal reason for the appointment of the Brabazon Committee, a year after Sir Graham Sutton had assumed the post of director. (The full report of the Brabazon Committee has not been published.) The difficulty of recruitment was partly due to the irregular hours of duty that must be served by the practising meteorologist and partly to the remote situation of many stations. Besides, there are few appointments for the trained meteorologist outside the Office, and it was common knowledge that opportunities for promotion to senior posts compared unfavourably with those in most other branches of the Scientific Civil Service. The reorganization that has now taken place will do much to remedy this state of affairs. New posts have been created in the highest grades of both the scientific and experimental officer classes and the total number of posts in the scientific officer class (145 at present) has been slightly reduced to ensure that all entrants in this class will have an expectation of reaching at least the rank of senior principal scientific officer within a reasonable period.

The further recommendations of the Brabazon Committee that have been promulgated in the annual report reveal that the scope of the Committee's survey has been wide. The continued progress and the high standing as a scientific institution acquired while the Office has been under the Air Ministry are taken to indicate that the Meteorological Office is in its right place in the Government organization. The post of director is raised to that of director-general, and there are now two directors in the grade of chief scientific officer, Dr. J. M. Stagg and Dr. R. C. Sutcliffe, responsible for services and research, respectively. In addition, there is a third section for administrative and general duties, headed by an assistant secretary, to be known as secretary to the Meteorological Office, a change which will presumably relieve the senior scientists of considerable administrative duties and at the same time make the Office a more self-contained unit.

The Meteorological Committee, established in 1919, is deemed to be too large and has been replaced by an Advisory Committee of "not more than five members, all outside Government service". Its functions are "to keep under review the progress and efficiency of the Meteorological Office and the broad lines of its current and future policy as well as the general scale of effort and expenditure". Its first chairman is Lord Hurcomb, and the members are Sir Austin Anderson, Sir David Brunt, Sir Charles Normand (*ex-officio* as chairman of the Meteorological Research Committee, which is to continue unaltered) and Col. Stopford Sackville.

The plans for improved facilities for research are imposing. Already, during the past decade, a steadily increasing series of papers, impressive both in quality and quantity, has come before the Meteorological Research Committee. This has been made possible by assigning many forecasting duties to experimental officers, so permitting the allocation of research tasks to the scientific officers, freed from operational work at out-stations. The tendency for delay in the practical application of the results of research is recognized by the appointment of a new assistant director, who will not only keep the forecasters acquainted with the progress of research that may be valuable to them but will also formulate, for presentation to the researchers, new problems that arise from the experience of the forecasters.

There appears, however, to have been no examination of the somewhat anomalous position of the three British magnetic observatories. Two of these,

* Annual Report on the Meteorological Office for the year April 1, 1957, to March 31, 1958. Pp. 52+4 plates. (M.O. 650.) (London: H.M. Stationery Office, 1958.) 3s. 6d. net.

at Lerwick and Eskdalemuir, are administered and staffed by the Meteorological Office, the third at Hartland Point (previously at Abinger) by the Royal Greenwich Observatory. The staff who have been posted to the Meteorological Office observatories have had to divide their allegiance between the almost unrelated sciences of meteorology and geomagnetism, for no senior post has been attached to the latter. Nevertheless, this association of geomagnetism with the Meteorological Office has been not unsuccessful, for the traditions established by Chree have been well maintained by Goldie, Stagg, and more recently, McIntosh and Lewis. Yet there is surely a strong case for the establishment of at least one senior observatory post so that a man of proved ability in geomagnetic studies, who wishes to devote himself to such work, may do so without sacrificing his prospects of promotion.

The annual report begins with a summary by the Director-General of the changes as they affect the Meteorological Office as a public service and scientific institution. In this, Sir Graham Sutton points out that the advantages of the reorganization will be fully realized only when the staff at present at Victory House, Harrow, Dunstable and the Training School at Stanmore move together to occupy the new buildings, now being erected at Bracknell and likely to be completed in 1961. There follows a detailed account by the Director of Services of the responsibilities of his directorate, which includes not only general forecasting for a wide range of customers, but also the complex organization of communications, the observations, both surface and upper air, on land and at sea, the climatological services, agricultural meteorology and training. The Director of Research summarizes the various problems now under investigation and discusses the work of instrument development, which is also his responsibility. Research on numerical forecasting, involving the development of techniques for predicting the pressure distribution by calculations from the dynamical and physical equations by means of an electronic computer, is being actively pursued. This very readable report concludes with two short chapters on international co-operation and administration.

With the recent rapid development of techniques for the measurement of the physical structure of the atmosphere to great altitudes and their wide use throughout the world during the International Geophysical Year, the mass of new data which is becoming available will make possible the investigation of many fundamental problems in meteorology that were hitherto intractable. The quite excellent facilities for this research which are now provided in the Meteorological Office have therefore been achieved at an opportune time, and it can be confidently anticipated that the national service will play an increasingly important part in advancing the science of meteorology.

J. Paton

SUPPLY AND DISTRIBUTION OF CHEMICAL ENGINEERS IN BRITAIN

THE Institution of Chemical Engineers, ever since its inception thirty-five years ago, has pressed for an appreciation of the importance of chemical engineering in the national economy and has made unceasing efforts to promote the training of chemical engineers; but development in Britain lagged far behind that in the United States, and it was not until the beginning of the Second World War, when the University of London was persuaded to institute a degree in chemical engineering, that the profession was generally recognized as a separate discipline. From that time progress was more rapid, and in recent years, following the national awakening to the importance of professional engineers and the multiplication of training courses, the number of chemical engineers has increased still more rapidly. The increase would have been greater still but for one factor, long foreseen by the profession—the ever-growing difficulty of obtaining qualified teachers. A state had been reached in which a promising graduate, immediately on leaving the university, could secure a higher salary in industry than some of those who had taught him. It was consequently not surprising that there were few candidates for teaching posts.

Earlier this year the Institution published a survey of output of chemical engineers in Great Britain, from which it was concluded that by 1966, provided the situation as regards teaching staff did not become worse, the yearly output might be about 950, as against a requirement of at least 1,100 (see *Nature*, 181, 1382; 1958). This would be an improvement on the present position but would still leave a shortage. Statistical information on this subject is scanty and the Institution has recently circularized its qualified members in order to ascertain where they work, in what industry and what position they hold. Salaries, unfortunately, have been omitted. 79 per cent made returns and it was hoped that these might indicate a special shortage of chemical engineers either in certain regions, industries or occupations. The results are interesting, but difficult to interpret; for example, the number of chemical engineers in a given region depends mainly upon the number of factories of a type employing a high proportion of chemical engineers (for example, oil refineries) which happen to be located in that region. It also depends on the prospects which the new recruit considers that these factories offer and on the amenities of the district. A low figure for any region does not necessarily indicate that many more chemical engineers are required there.

The returns showing the occupation of members are more illuminating, as they can be compared with similar figures for 1953. In that year, about 20 per cent were engaged in each of four main branches: (1) administration and management; (2) plant operation and maintenance; (3) design and construction; and (4) research and development. In 1957, no less than 30 per cent were occupied in administration; a remarkable increase, due, perhaps, to the multiplicity of subjects, not all purely technical, which chemical engineers have to study and the wide outlook which results. This increase is offset by a reduction from 22·8 to 12·3 per cent in the numbers engaged in the operation and maintenance of chemical plant, and is a welcome sign

since it not only indicates the advancement of automatic control but also a diminution of the employment of graduates in duties which could be carried out equally well by those with lower qualifications. It is surprising to find that corresponding figures for two of these major branches in the United States differ considerably, being 31 per cent for research and development compared with 23 per cent in Britain, but only 7 per cent for design and construction against 21 per cent, a possible explanation being that development may be carried further in the United States and may include much which is classed as design in Britain. Among the minor occupations, teaching shows a gratifying increase from 3·0 to 5·1 per cent, the present number of teachers being more than 100, but this is still not enough.

The total number of qualified members of the Institution in 1957 was 2,176, a figure considerably higher than that given in the Government report on Scientific and Engineering Manpower in 1956. The distribution of these members among thirty-three different industries and occupations is shown and also the number of chemical engineers per 1,000 males employed. As might be expected, the mineral-oil refining industry, which may be regarded as the cradle of chemical engineering, heads the list with 7·3 chemical engineers per 1,000 employed, and it may also be noted that it was calculated some years ago that the value of the product per man-hour in the oil industry was far higher than in any other heavy manufacturing industry. Oil refining seems to be approaching a state in which the only labour required will be for the erection and maintenance of plant, operation being entirely automatic, and its chemical engineers are employed in research, design, development and management. It would, however, be unwise to conclude from this that the efficiency of an industry is directly related to the number of chemical engineers employed. The iron and steel manufacturing industry, in which many chemical engineering processes are involved, employs only twenty chemical engineers, or 0·05 per 1,000 males, and is at the bottom of the list. It is true that automatic operation has not been adopted in this industry to the same extent as in the case of oil, but this is doubtless because it would be more complicated and difficult to install, and would probably be uneconomic. There is certainly no question of the iron and steel industry being inefficient, but there is a possibility that it does not recognize fully the potentialities of the chemical engineer, and that many of the highly qualified staff who are, in effect, doing chemical engineering work were recruited as metallurgists or mechanical engineers. This example may show the difficulty of interpreting employment statistics.

Of the other items in the list of industries, one is deserving of particular attention, namely, atomic energy. This has already secured the services of more than one hundred chemical engineers, and it seems certain that the number required in the near future will be very large.

All the figures now published will have their real value in the future. It is to be hoped that a similar set will be published in about five years time, and it may then be possible to make reliable predictions. Even now, it may be regarded as a practical certainty that there will be no over-production of chemical engineers in the coming quinquennium.

H. E. Watson

FUEL AND POWER IN BRITISH INDUSTRY

IT is abundantly clear that the supply of suitable fuels and the provision of adequate power represent essential factors in any efficient industrial unit. It may well be doubted, however, whether, in view of the ever-increasing complexity of the situation, those responsible for important industrial decisions are always in a position to appreciate thoroughly all the technological and commercial factors involved. It was in the hope of doing something to assist in the planning of such development, so far as the supply of fuel and power is concerned, that the Manchester Joint Research Council arranged a symposium during November 5–7, which was held at the Manchester College of Science and Technology. A very large amount of material has been published on these matters from the technological point of view, and it was not the intention of the Council in organizing the symposium to duplicate this, the general theme of the meeting being the interaction between technological advances and their economic consequences.

The meeting was opened by Lord Mills, Minister of Power, who summed up the Government's policy as permitting the consumer to decide from his own experience what is required to meet his own particular needs, coupled with the provision of expert advice, where this is required. It has been estimated that by 1965 the total fuel consumption of the United Kingdom will have risen to about 300 million tons of 'coal-equivalent' a year and to 350 million tons by 1975. A marked change in the pattern of the fuel and power used is to be expected; there will probably be a continued switch from the direct use of raw coal to its application in the more refined forms of gas and electricity and an increase in the use of oil, due to the continued expansion of road transport, the re-equipment of the railways, the continuance of recent trends in domestic heating and the change from solid fuel to oil in those industrial and commercial uses where it has special attractions.

This greater refinement means heavy capital investments but offers great savings both in operating and fuel costs, and, in addition, there is a marked reduction in the atmospheric pollution associated with the use of solid fuel.

It is often argued, the Minister said, that the Government should direct the fuel to be used for specific purposes. In reply to this he added: "We should certainly hesitate to adopt such a policy of Government direction on fuel use for two main reasons. In the first place, the detailed policy of control could not really work; there is so much uncertainty regarding the best fuel to employ in particular conditions and, secondly, if there is one thing which central control lacks it is flexibility. A pattern laid down as appropriate at a particular time might quickly become obsolete and uneconomic". It is important, too, in his view, that the importation of oil should be in the crude form, from an increasing variety of sources and processed at refineries in the United Kingdom.

So far as nuclear power is concerned, there would be a rapid expansion to some 5,000–6,000 megawatts in 1966, and thereafter continued expansion may prove economic. Concerning the use of small coal, this should become progressively a more attractive purchase, and it is the duty of all forms of industry, nationalized or otherwise, to switch their demands so far as possible from larger sizes to small coal.

The remainder of the meeting was devoted to the industrial consideration of oil, coal, gas, electricity and nuclear energy. The lectures on oil were given by Dr. P. H. Frankel, of Petroleum Economics Ltd., who dealt with the economic aspect, and Mr. W. S. Ault and Mr. H. Cunliffe, both of Shell-Mex and B.P. Ltd., who were concerned with the uses. Dr. Frankel, in a most valuable and provocative paper, suggested that with the expansion of existing oil-fields and the opening of new ones—the Sahara was mentioned in particular—there would appear to be abundant reserves on a world scale. Great Britain, however, is especially subject to political vicissitudes, and he therefore stressed the need for a balanced fuel economy. In the past few years vast new oil fields have been found, the exploitation of which, now that they have been located, should be relatively cheap. This oil will tend to press on the existing markets, and he assumed, therefore, that the price of liquid fuel would tend to fall. A question which he posed to the Conference was whether it is more economic for Great Britain to go to the limit of marginal high-cost production of coal with investment on a commensurate scale, or to substitute oil for, say, the last 10 per cent of our requirements. He pointed out that Western Europe is dependent on sea-borne oil, but he believes that there are plenty of tankers available, while pipe-lines based on Marseilles, Rotterdam and Hamburg would facilitate distribution.

Mr. Ault and Mr. Cunliffe's paper on the uses of oil, after stressing its importance in all forms of transport, passed on to consider its use in general industry. Although electrical energy can be produced from coal at the generating station at the lowest cost, there are even here special cases in which oil-firing is worthy of consideration. The efficiency of combined generation of electricity and recovery of waste heat, using either Diesel or gas turbine or both, was given as 80 per cent. The storage space required for oil fuel is much lower than that needed for coal, and oil firing offers further advantages in mechanical equipment, labour costs, convenience and automatic control. Furnaces may be heated by a wide variety of fuels, ranging from propane to heavy fuel oils, and in such processes as steel-making the high radiation from the flame leads to more rapid melting. The question of atmospheric contamination by sulphur was mentioned, though in subsequent discussion it was not clear that, from this point of view, oil is markedly superior to coal. It does, however, possess marked advantages in the absence of grit turned into the air.

In his review of Britain's resources of coal, and considering seams not less than 1 ft. thick and not more than 4,000 ft. deep, Mr. A. M. Wandless (National Coal Board) estimated that these are of the order of 1,000 million tons which can be economically worked. He stressed the fact that it is not the mere quantity available but the 'rank', of which the coals proved cover a range unique in Western Europe. With the increase of mechanization the increased costs of production are not likely to go on rising unchecked. This cost of production varies inversely with the rank, of which the various industrial uses extend over a wide range, and low rank does not necessarily imply low quality. The present output of the various types of coal is not seriously out of phase with the resources of Britain, though a slow decline in quality must be expected. About half the output is of low rank, and it is for the technician to ensure that the use of such coal should be as great as possible.

One of the most important contributions was that of Mr. D. Hicks (National Coal Board), on "Coal Utilization". Although the total mineral resources of Britain are limited in type, they are not insignificant in quantity. There is, for example, enough economically accessible coal to sustain a high national productivity for more than a hundred years. It would seem wise to ensure that these natural advantages are not used carelessly, and that we do not become increasingly dependent on external resources, with all the uncertainties and risks, political and economical, that this implies.

From the commencement of the industrial revolution there has been a fairly direct relationship between national income and the consumption of primary fuels, and estimates of the future demands of fuel and power have been based within fairly wide confidence limits on an extrapolation of this relationship. In industry the maximum utilization of time and resources has not yet been achieved, and big improvements in productivity are possible with a smaller expenditure of mechanical energy than extrapolation from past performance would suggest. Mr. Hicks recognized that we cannot sustain a high industrial output in Britain wholly on our internal resources; neither can we support our economy without importing some oil, particularly for our air and road transport systems, for lubrication and for certain chemical feed stocks. He asked, however, whether it is not a matter for serious consideration whether we should become increasingly dependent for heating and for power generation on imported fuel. In pleading for an increased efficiency in the use of fuels of all kinds, Mr. Hicks pointed out that it is too facile to assume that merely by switching from one fuel to another an automatic improvement in efficiency will result. All fuels, both primary and secondary, require close attention to the choice of equipment and to the operation. It is far less costly, ton for ton, and takes far less time to save coal than to create a new pit.

In his lecture on "Gas", Sir Harold Smith (of the Gas Council) emphasized that the industry is passing through a period of change, perhaps the most important in its whole history. It is facing two new challenges, one due to the increasing shortage of suitable fuel and the other from nuclear power, and is meeting these challenges by basic experiments from which a new gas industry may be developed. New types of coal and new materials are being investigated, and in particular the high-pressure–high-temperature gasification of small, low-quality coal. The collection and distribution of methane from mines and from catalytic plants should make a further useful addition to the supplies available, and he particularly emphasized the interest being taken in the importation of liquid natural gas from America. A thirty-thousand ton tanker would be capable of carrying the equivalent of two million tons of coal. Gas has advantages as an industrial fuel due to its ease of control and the very wide range of temperature which can be obtained.

In the discussion, Mr. D. P. Welman (North Western Gas Board) envisaged the transformation of the existing industry into a truly chemical one, and mentioned the experiments of the North West Gas Board in the development of the hydrogenation process which, if as successful as appears probable at the moment, may well revolutionize the whole industry. The preliminary work will take some four to five years, and a further three or four years will be required to construct a large-scale plant. He concluded by claiming that the gas industry uses coal more efficiently than any other major industry does.

"Nuclear Power" was discussed by Mr. P. T. Fletcher (United Kingdom Atomic Energy Authority). Broadly speaking, the capital cost of the present plant is three times that of a conventional coal-fired generating station. The fuel costs, however, are about a half, so that there is not very much to choose for base load operation between the cost of power generated in the two ways. If, however, the bigger and more advanced stations which are envisaged materialize, the cost per unit of electricity generated from nuclear energy may fall as low as 0·4*d.* per unit. A point of great importance in connexion with nuclear power stations is the load factor, which is more important than with coal. So far as the gas-cooled reactor is concerned, the three main lines of development are an increase in the temperature of the gas leaving the reactor, the design of the fuel elements so that heat is transferred to the gas more effectively—thin rods stacked in clusters in uranium oxide were suggested in this connexion—and reduction in capital cost by simplification of lay-out. Considerable interest was expressed in the future of the boiling-water reactor using enriched uranium or plutonium as the fuel, a system which, it was suggested, would result in marked reductions in the initial capital cost. Mr. Fletcher expressed the opinion that it is justifiable to spend £40–£50 million on experimental work when the potential saving might exceed £200 million. The cost of a prototype plant from the initial laboratory stage is of the order of £20 million, and he believed, therefore, that two such prototypes may justifiably be designed. In the discussion, Mr. M. Zvegintzov (National Research Development Corporation) stated that about twelve times as much money is being put into research in connexion with atomic energy as into all other fuel projects, and asked what the coal or gas industries could do if they had the £50 million for development purposes which Mr. Fletcher suggested for nuclear power. It is still, in Mr. Fletcher's view, very difficult to predict the next stage of development, and even the present programme of research and development will take many years to complete. He was sure, however, that the present United Kingdom pattern of nuclear development was justifiable both economically and technically.

The lectures on "Electricity", by Mr. T. E. Daniel and Mr. A. O. Johnson, were devoted, in the main, to a consideration of its use in electro-heating. It was pointed out that the consumption doubles every ten years, and the view was expressed that the future trend of price should tend increasingly to favour electric energy. The largest single user in Britain is the steel industry, but it was suggested that electrical heating would eventually displace fuel-fired furnaces both for the melting and annealing of glass, and in the ceramic and refractory industries. Advantages of electric heating are its flexibility, the possibility of thermal storage, so far as space heating is concerned, and the extent to which, by adequate instrumentation, its utilization could be rendered automatic. In modern conventional power stations an efficiency of 35 per cent can be obtained, and by a marked increase in size 37–38 per cent would not be unreasonable. Both in the lecture and discussion the possibility of extended use of the heat pump was mentioned, which, in the view of Mr. Frank Rostron (Ferranti Ltd.), has great possibilities when it can be built into the structure.

The final session was devoted to a general discussion with particular reference to future trends. Mr. G. A. J. Begg (Imperial Chemical Industries Ltd.) dealt with the chemical industry and gave figures illustrating the marked economies which have been achieved during the past forty years; despite these figures, the curve has not yet become asymptotic and further economies may reasonably be expected. Much depends on the elimination of heat losses by the use of waste-heat boilers and in general the recovery of low-grade heat. The siting of factories in relation to generating stations is an important point, as is the private generation of electricity in industry, the three such main producers being the chemical industry itself, the iron and steel industry and paper-making. In small plants oil has great advantages, but throughout capital cost is a basic factor.

The metallurgical industries were discussed by Dr. T. P. Colclough (British Iron and Steel Federation), who pointed out the astonishing economies in fuel which have been achieved in the past thirty years. In 1927, the consumption amounted to 55 cwt. per ton of finished steel; this had been reduced in 1957 to 28·5. Sintering, the recovery of waste heat, the effective use of blast furnace and coke-oven gas and oil firing have been the major reasons for this. The use of oxygen in the open-hearth furnace to increase the rate of combustion and therefore of refinement is a comparatively new technique, which may well have very marked future influence. In this connexion there is a vast new field in the pneumatic (Bessemer) processes which, with tonnage oxygen available, are opening up a new era.

The trends in general industry were discussed by Dr. W. A. Macfarlane (National Industrial Fuel Efficiency Service), who said that in the past ten years the increase in the energy used in Britain in general industry has been about 40 per cent, and attention was directed to the relatively enormous economies which could be effected by more careful attention to the factors leading to increased efficiency. He believed that 20 per cent of the fuel used could thus be saved.

One may, in conclusion, quote some words of Sir Raymond Streat, spoken at the conclusion of a series of meetings on "Science and Industry", arranged by the Manchester Chamber of Commerce in 1944, to which Mr. Hicks made reference: "If you came to this meeting hoping to have a simple answer served up on a platter, you will be disappointed. You have to wrestle with this matter each for himself. Heavy reading, hard study, anxious thought, persistent inquiry, costly experimentation—these are unavoidable and you will drop behind if you cannot stand the pace. It is going to be a difficult, testing life after the war, but full of interest and reward for those that can take it". It is now more than fourteen years since these words were spoken, but they still apply, and particularly so in respect of the problems of fuel and power.

F. C. Thompson

THE LIBRARY ASSOCIATION

CONFERENCE AT BRIGHTON

THE papers presented at the annual conference of the Library Association at Brighton during September 23–26 ranged over a wide field, but the two of most direct interest to the scientist are those in which Mr. W. L. A. Saunders, deputy-librarian, University of Sheffield, discussed current problems of university libraries, and Mr. C. H. Wright, county technical librarian, Hertfordshire, those of special libraries.

Prof. Raymond Irwin in his presidential address reviewing the work and technique of librarianship, including committee work and the place and value of conferences, insisted that librarianship was all directly and closely connected with books and their proper use. The librarian's first responsibility was to help others to read or to find information. His second responsibility was to read himself: to read intelligently, systematically; widely but not aimlessly; with understanding, with sympathy and with appreciation. No routine should be tolerated which hindered rather than helped the discharge of these responsibilities, and Prof. Irwin urged an honest and unprejudiced review of all routines. Books, he insisted, were never more alive than to-day: there was no substitute for the book and there never would be. Finally, insisting on the importance of the librarian himself and the limitations of administrative and bibliographic techniques, Prof. Irwin said that British librarians and librarianship were to-day being exported to Australia, Africa, the Middle East, Canada, the Caribbean and the United States, but there was grave need to increase the export of British books, particularly scientific and technical books, to many parts of the world besides Pakistan. With these books must go British ideas about books and about librarianship, and he hoped we would continue to send out both British librarians and British-trained librarians.

Mr. Saunders said that the main problem facing universities and university librarians at present arises from the increase in the student population, from 50,000 in 1939 to 90,000 at present, with at least 124,000 expected by 1965. At Sheffield it had risen from 767 in 1939 to about 2,000 in 1952, and early this year a target of 4,500 was set. The increase had already set a severe strain on storage space and seating accommodation in many libraries, and the latter was aggravated by the fact that a relatively small proportion of students lived in halls of residence. Few university libraries held excessively large collections, but several were near the 400,000 and 500,000 marks, and in twenty or thirty years many provincial university libraries were likely to approach a million volumes. Collections of this order could daunt new students, and the problem of providing an adequate introduction for an annual intake of several hundred students was serious. In addition to an introductory tour, Mr. Saunders suggested that all undergraduates should at least be made aware of the bibliographical tools of their own field. The whole question of departmental libraries required objective review, and finally he stressed the importance of providing a reasonable salary scale for non-graduate staff so as to attract those capable of relieving the graduate staff of work which did not require high academic qualifications.

Mr. C. H. Wright, pointing out that the special library in the past was chiefly concerned with the flow of information, whereas the public and university libraries were concerned with the flow of books, said that with the vast expansion of scientific and technical literature, the mechanics of organizing the flow of information had become as important to the special librarian as the degree of subject knowledge, while the increasing demand for scientific, technical and commercial information had made the public librarian more aware of the value of specialized subject knowledge. There was thus a better understanding of what are the common foundations of librarianship. After reviewing the problems of staffing a special library and suggesting that more attention should be given to the question of providing suitable training, Mr. Wright said that the present national system of co-operative loan service did not meet all the day-to-day requirements of the industrial or commercial library, and while the National Lending Library for Science and Technology might solve many problems, it appeared likely to be many years before its service could be put to the test. All the investigations made had illustrated the need for local information services and liaison between all the parties concerned. Local schemes of co-operation, however, required a few paid servants to implement policy if co-operation was to be effective. Mr. Wright thought that it was a pity that, in spite of its vital interest in the free flow of information, the Department of Scientific and Industrial Research should be unable to offer financial support to areas where librarians were anxious to co-operate but unable to provide the necessary staff. Such support should be conditional on industry and local authorities continuing to provide an adequate flow of scientific and technical literature. Finally, he referred to the opportunity for a co-operative research organization capable of producing more efficient microtext readers, information retrieval units, and simple photocopying apparatus.

In the course of a paper reviewing the publications and catalogue service of H.M. Stationery Office, Mr. P. McGrath, director of publications, said that the Stationery Office had again been reviewing its catalogue practice and had decided to initiate informal discussions with representative librarians with the view of achieving a compromise which might yield a catalogue more suited to modern requirements. Mr. G. A. Carter, borough librarian of Warrington, in a paper reviewing capital expenditure on building, included both public libraries and school libraries and also libraries in industry (but without giving costs) and in universities, where the estimated cost of five new library buildings due for completion next year was £1,925,000, roughly equivalent to the total expenditure on all new public library buildings in the past twelve years, although in all fourteen university libraries the book stock had increased by only 1·5 million compared with 24 million in public libraries. Mr. Carter also cited figures showing the extreme variation in expenditure on libraries by different

local authorities, and he, too, insisted that the new National Lending Library for Science and Technology would not dispense with the need for technical libraries in the municipal and county library systems.

In a stimulating paper of some general interest, Dr. J. Trenaman, liaison officer for further education, British Broadcasting Corporation, under the title "Libraries as a Social Force", described a survey of opinion towards broad educational ends, from which he concluded that about 55 per cent of those in the sample were at least receptive to new and even unwelcome ideas, while the remaining 45 per cent were resistant, at least to the extent of avoiding unaccustomed ideas or not being interested. This resistant sector had usually received only an elementary early education, whereas those who were interested in education had had a fairly good early education, about half having been to a secondary school. They were interested in the more serious radio and television programmes and were also members of a library. There was an upper level of 25 per cent of the whole sample who had mostly received a grammar school education, with a keen interest in further learning and who would be the more serious readers in the libraries. Dr. Trenaman believes that the machinery of education as a whole operates selectively, and accordingly the chief responsibility for adult education rests upon the informal agencies, especially the public library service, the Press and the broadcasting authorities because they have an access denied to all other information agencies. He also emphasizes the profound and durable influence of our early education.

EFFECTS OF PLANT DECOMPOSITION PRODUCTS IN THE SOIL

THE inhibitive effects, on the germination of seeds and on seedling growth, of products from decomposing plant materials in soil have been examined by Z. A. Patrick and L. W. Koch (*Canad. J. Bot.*, **36**, 621; 1958). Substances capable of inhibiting the respiration, germination and growth of tobacco seedlings were obtained after residues from timothy, corn, rye or tobacco plants had been allowed to decompose under appropriate conditions in the soil. Bio-assay tests, based on manometric methods, made it possible to determine some of the conditions under which the decomposition gave rise to phytotoxic by-products and to obtain rapidly an accurate measure of the degree of their toxicity.

Among the factors affecting the production of the toxic products, the species and stage of maturity of the plant material added, the water content and *p*H of the soil, and the length of the decomposition period, were the most important. Substances capable of reducing the respiration of tobacco seedlings by 50–90 per cent were consistently obtained when any of the plant residues examined had been decomposing for 15–25 days under conditions of high soil moisture and a *p*H value of the soil solution below 5·5. Timothy yielded substances with the highest toxic activity, followed by corn, then rye, and finally, tobacco. Aqueous extracts of unamended soil or of macerated tissues, prepared either before decomposition or when decomposition was inhibited by autoclaving, were not toxic. The toxic substances, obtained by water extraction, showed an inhibiting effect on respiration of tobacco seedlings after an exposure of less than one hour and also induced darkening and necrosis of root cells. Some extracts affected the cells of the apical meristem most severely while others affected only the cells of the elongation region.

The toxic substances have not yet been identified, but they were relatively non-specific in their action, affecting several test plants in approximately the same manner. Many of them possessed antifungal activity. They were soluble in water, insoluble in petroleum ether, stable in acid, and most active in the *p*H range 4·5–5·8. They were precipitated by alkali and their activity was markedly reduced when they were readjusted to the acid-range. They were also stable to heat and did not lose their activity in storage at 1–3° C. provided they were covered by a layer of toluene. Because of their rapid production and their marked injurious effects on various plants, the authors consider that these toxins may be important under field conditions as the primary factor in some root rots and in predisposing plants to attack by organisms not normally regarded as being pathogenic.

THE NATIONAL INSTITUTE OF AGRICULTURAL BOTANY

THE report for 1957 of the National Institute of Agricultural Botany has recently been published*. The Trials Branch of the Institute has, as usual, carried out an extensive programme of work and the performance of a large number of varieties of the main agricultural and horticultural crops has been assessed. A very special requirement of sugar beet varieties is resistance to bolting, and the results are given of a special series of early-sown sugar beet trials designed to test resistance to premature flowering. The new variety from the Cambridge Plant Breeding Institute, known as Cambro, gave less than 1 per cent of bolters compared with commercial varieties where the percentage varied from 5 to 20. The potato trials have included for the first time a number of foreign varieties from the Continent and North America. The work of the Seed Production Branch has continued to expand, and as well as administering the various field approval and seed certification schemes the Branch has intensified its inquiries into problems of seed production.

The report covers the first full season of operation of the national scheme for the comprehensive certification of herbage seeds. In launching a scheme covering 25,000 acres in its first season, the

* National Institute of Agricultural Botany. Thirty-eighth Report and Accounts, 1957. Pp. 56. (Cambridge: National Institute of Agricultural Botany, 1958.)

certifying authority needed, and was fortunate to receive, the full and willing co-operation of all participants. Some 824 growers and 93 merchants took part in the production of 53,500 cwt. of British certified seed. With the co-operation of the Seeds Branch of the Ministry of Agriculture, Fisheries and Food, check samples were drawn from most lots of certified seed and have been tested and then grown in plots for verification purposes. The Official Seed Testing Station received a very similar number of samples in the year under review compared with the previous year, but the proportion of cereals to clovers and root and vegetable samples was much greater because of the very different weather conditions experienced in the two years. The number of samples of each variety of cereal received for testing is some indication of the relative popularity in the country as a whole, and this information is summarized in a table. A notable feature is the disappearance from the list of four old-established varieties, Squarehead's Master, Wilma, Holdfast and Minister. Among the barley varieties, the proportion of Proctor has further increased. The report refers to a number of building developments, including extension to the main building, a cold store and a new glass house.

THE COLOMBO PLAN

THE sixth annual report* of the Consultative Committee for the Colombo Plan for co-operative economic development in south and south-east Asia, as usual, is in three parts. The first includes a general review of economic progress in the area and of the task ahead; the second summarizes the position in individual countries; and the third directs attention to some contributions to economic development made under the Plan and summarizes the contribution of technical assistance in particular.

Further progress in economic development in the area is recorded and the growth of *per capita* real income appears to have been maintained in spite of balance of payment difficulties and increased internal inflationary pressures. Agricultural production, as well as industrial and mining output, in general, showed an upward trend, but exports did not keep pace with the expansion of imports; prices of some of the main products of the Colombo Plan countries fluctuated, and as a result of these fluctuations and of higher prices of imports, the terms of trade worsened for many countries in the region.

Several countries in the region have now approved development plans, and all are evolving programmes designed to accelerate development. Experience in 1957, however, has emphasized the risk that the pace of development may outrun the availability of resources, and consequently the implementation of development plans should permit re-phasing to match the resources available. Once again, the report stresses the desirability for the countries of the area to pursue policies which serve to attract capital, domestic and external, into development projects and to assure the effective utilization of such capital. A pointed reference is made to the need for consideration of such factors as apprehensions as to the security of investment, difficulties with administrative and financial procedures and restrictions, and uncertainties about the incidence and weight of taxation, all of which could offset the attractions of the region.

Again, the problems of the different countries vary considerably, and accordingly the methods of meeting their needs vary widely also. This is brought out particularly in technical assistance, where some countries need help mainly in the shape of highly qualified missions specially equipped to deal with the planning or implementation of major projects, while others seek quite simple skills. It is important that technical assistance should fit the individual needs of each country, and continuing care is required to ensure that technical resources are not wasted. Continual reference is made in the report to the search by the countries of the area for additional resources, more capital, more equipment, and more managerial and technical skill. Although there are signs of strain in some of the more highly developed as well as in the less-industrialized countries, the situation is not regarded as discouraging, because there are signs that the urgent tasks of development and the raising of living standards are being tackled with speed and energy.

Since 1950, training has been extended to about 13,000 trainees from countries of the area, while about 6,000 experts have been provided by Colombo Plan members and United Nations agencies. Australia alone has contributed £3,440,019 to technical assistance, and during 1956–57 spent £5 million on capital and technical assistance, including £200,000 on technical equipment. Another 439 trainees were received and sixty new appointments of technical experts were made, bringing the total in the field in June to sixty-six. Canada's contribution to capital projects and technical assistance amounts to 196·7 million dollars, of which 34·4 million will be for 1957–58, and more than 4 million dollars (1·4 million dollars in 1956–57) on technical assistance. Since 1951, 712 fellows and scholars have been trained in Canada, and 201 of these were still there in June 1957, while 100 experts have been sent abroad, of whom 35 are at present carrying out assignments in seven centres. New Zealand's contribution for capital and technical assistance will amount to £7 million by June 1958, expenditure on technical assistance totalling £744,000 by June 30, 1957, under which training had been provided for 459 persons (148 in 1956–57) and 72 New Zealand experts provided (16 in 1956–57).

The United Kingdom has since 1951 made available to countries in the area, by way of grants, loans, credits and technical assistance, £92 million, including £2·7 million for technical co-operation up to June 30, 1957, with forward commitments of £1,275,000. Of this, £862,540 has been for research and training equipment, with further commitments of another £786,895. By June 1957, 1,582 trainees had been taken, including 333 from non-Commonwealth countries, and in collaboration with the United Kingdom

* Colombo Plan for Co-operative Economic Development in South and South-East Asia. Sixth Annual Report of the Consultative Committee, Saigon, Viet Nam, October 1957. Pp. 166. (Cmnd. 315.) (London: H.M. Stationery Office, 1958.) 6s. net.

steel industry and the Government of India up to 300 Indian steel workers are to be trained in the United Kingdom for managerial and technical posts at the new steel works at Durgapur. Of 263 experts provided by the United Kingdom, 23 have gone to non-Commonwealth countries. United States Government economic and technical assistance to Colombo Plan countries during the year totalled 900 million dollars, bringing the total since 1950 to more than 3,000 million dollars. During the year, more than 1,000 technicians and students were taken to the United States under the Mutual Security Programme and 500 sent to third countries such as Japan and the Philippines, while about 550 were taken to the United States under the United States International Educational Exchange Programme. Representatives of sixteen nations of the Colombo Plan Consultative Committee met as a working group in Washington to discuss the United States offer of assistance for establishing a regional nuclear centre to serve the needs of the participating countries.

Summarizing the contribution made by technical assistance, the report recognizes that the world scarcity of technical man-power must limit the supply available for the Colombo Plan. By June 30, 1957, expenditure on technical assistance was more than £8 million, including £1·8 million on equipment, and 1,858 persons were receiving training, although the number of new training places declined from 1,552 to 1,395. At the end of the year about 1,400 experts were assigned to countries of the area. Stress is laid on the scope for help from outside the area in developing adequate training institutions, although success depends primarily on the initiative of the institutions themselves, and also on the encouraging increase in the number of countries in the region now providing training places to other countries in the region (Ceylon, India, Indonesia, Malaya, Pakistan, Thailand and Singapore) as against three countries in the previous year. The technique of team work is being used to an increasing extent and within the United States programme some thirty contracts have been arranged with universities of countries within the area to help them develop curricula, teaching methods and research facilities as well as adequate laboratories and libraries.

INTERACTION OF FORMALDEHYDE AND TETRAHYDROFOLIC ACID AND ITS RELATION TO THE ENZYMIC SYNTHESIS OF SERINE

By Dr. R. L. BLAKLEY

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THE reaction between glycine and formaldehyde to form serine in the presence of an enzyme from liver[1] requires, as a co-factor, tetrahydrofolic acid (FH_4, I), which is believed to act by forming a reactive complex with formaldehyde. The structure of the 'active formaldehyde' was first postulated as N^5,N^{10}-methyleneFH_4 (III) in 1954[1], although N^5-hydroxymethylFH_4 (II) is also a possible structure[2]. Formaldehyde is bound strongly by 1 : 2-diamines with the formation of bridged structures. Thus it was demonstrated that N,N′-diphenylethylenediamine reacts readily with formaldehyde to give a stable cyclic product[3]. It might be expected, therefore, that FH_4, which is also a 1 : 2-diamine, would react with formaldehyde to give III, and that this compound would be stabilized to oxygen by the presence of the firmly bound methylene bridge. Although the product of formaldehyde reaction with FH_4 was found to be somewhat more stable than FH_4 itself, it was nevertheless very sensitive to oxygen, for in aqueous solution it rapidly lost coenzyme activity when shaken under air[3]. This sensitivity to oxygen has been confirmed by spectrophotometric studies. When a solution of FH_4 is diluted with phosphate buffer (*p*H 7·2) to a concentration of 5×10^{-5} *M* the spectrum changes within a few minutes from that of FH_4 ($\lambda_{max.}$ 298 mμ) to that of oxidized products with $\lambda_{max.}$ at shorter wave-lengths (finally 275 mμ). If the diluent contains formaldehyde the rate of change due to oxidation is less, but even in the presence of 10^{-3} *M* formaldehyde it is about 3 per cent of that occurring in absence of formaldehyde. In this laboratory, paper chromatography of reaction mixtures has yielded no clear separation of a product with R_F different from that of FH_4 as reported by others[4].

These results were at first interpreted as indicating that II must be the structure of the product, and that it must readily dissociate[3,5]. Investigation of the binding of formaldehyde labelled with carbon-14 by FH_4 and related hydropteridines indicated that approximately one molecular proportion of formaldehyde was bound by FH_4, smaller amounts by N^{10}-formylFH_4 and 2-amino-4-hydroxy-6-methyltetrahydropteridine and a negligible amount by leucovorin[5]. These results have been confirmed and extended by determination of the formaldehyde concentration in equilibrium with known concentrations of hydropteridines. Since tetrahydropteridine is rather unstable, tetrahydroquinoxaline, a close

Table 1. Approximate Dissociation Constants for the Products formed by the Reaction of Formaldehyde with Hydropteridines and Tetrahydroquinoxaline

	Base	Dissociation constant of product = $\frac{[HCHO]\,[base]}{[product]}$
Group *A*	FH_4	0·0004
Group *B*	FH_2	0·01
	N^{10}-formylFH_4	0·01
	N^{10}-methylFH_4	0·03
	2-Amino-4-hydroxy-6-methyltetrahydropteridine	0·04
	4-Hydroxy-6-methyltetrahydropteridine	0·04
	Tetrahydroquinoxaline	0·01
Group *C*	N^5-formylFH_4 (leucovorin)	0·41
	N^5-formyl-4-hydroxy-6-methyltetrahydropteridine	0·45

structural analogue, has also been studied. The results are given in Table 1.

The last two compounds of group *B* are substances which contain only heterocyclic nitrogen, and may be presumed to form hydroxymethyl groups by reaction with formaldehyde. The similarity of the dissociation constants for the products formed by all members of this group suggests that hydroxymethyl groups are formed in all cases, and this is in accord with the fact that methylene bridge formation is precluded in N^{10}-formylFH_4 and N^{10}-methylFH_4.

The very high dissociation constants of complexes formed by group *C* compounds in which a formyl group is substituted on the N^5 position may be interpreted to indicate that N^5 is the essential site for formaldehyde combination with hydropteridines (as previously postulated[5]) and that no other single grouping in leucovorin (for example, N^3, N^8, N^{10} or 2-amino) can provide a strong binding site for formaldehyde. This is in contradistinction to recent hypotheses of multiple binding sites in FH_4 for formaldehyde[4]. It also indicates that N,N′-diphenylethylenediamine cannot be considered a true model for FH_4 in its reaction with formaldehyde. However, the unparallelled combination of formaldehyde with FH_4, in which both N^5 and N^{10} are unsubstituted, suggests that in this molecule both these sites are concerned with formaldehyde binding; since only one molecular proportion of formaldehyde is bound, it seems probable that methylene bridge formation occurs.

Another possible explanation of the relatively high dissociation constants of the complexes formed by formaldehyde with group *B* bases concerns the protonation of the N^5-amine group. In these compounds the N^5-amine group might have a *pK* high enough to result in significant protonation at *p*H 7 and it might be this protonation of N^5 which prevents the reaction with formaldehyde from proceeding to completion. In FH_4, on the other hand, the N^5-amine group may be assumed to have a *pK* well below 7, and thus to be unprotonated at this *p*H. This possibility was tested by determination of the *pK* values of the N^5-amine and 4-hydroxy groups of 4-hydroxy-6-methyltetrahydropteridine. Two groups with *pK* values of 10·2 and 4·1 were detected. The similarity of these to the *pK* values of 9·86 for the hydroxy group and 3·57 for the 5-amino group in the related 4,5-diamino-6-hydroxypyrimidine[6] indicates that in 4-hydroxy-6-methyltetrahydropteridine the *pK* of the N^5-amine group is 4·1. Spectrophotometric studies indicated that no groups in 4-hydroxy-6-methyltetrahydropteridine had a *pK* between 4 and 10. Moreover, no increase in formaldehyde binding occurred at *p*H values above 7. Since differences in the *pK* of the N^5-amine group cannot, therefore, account for the difference between the dissociation constants of group *B* complexes and that of the FH_4-complex, methylene bridge formation in the latter is clearly indicated.

Studies of the rate of reaction of 4-hydroxy-6-methyltetrahydropteridine (4×10^{-3} *M*) with formaldehyde (4×10^{-4} *M*) indicated that equilibrium was reached in a few minutes. Binding of formaldehyde by FH_4 (both at an initial concentration of 4×10^{-4} *M*) was also rapid—80 per cent of the formaldehyde reacting in the first minute. This rate of combination far exceeds those which have been attained for enzymic synthesis of serine, so that enzymic catalysis of the combination appears unnecessary and in fact did not occur with partially purified preparations of serine transhydroxymethylase.

Table 2. Absorption Spectra of FH_4 (5×10^{-5} *M*) in presence of 2,3-Dimercaptopropanol (10^{-3} *M*) Phosphate Buffer *p*H 7·0 (10^{-1} *M*) and various Concentrations of Formaldehyde

Formaldehyde concentration *M*	$\lambda_{max.}$ (mμ)	$\varepsilon_{max.}$ (mol.)
0·0	298	23,400
$6{\cdot}67 \times 10^{-5}$	297	29,000
$1{\cdot}5 \times 10^{-4}$	296	30,800
10^{-3}	294	32,000

The combination of formaldehyde with the bases in Table 1 has also been studied spectrophotometrically. FH_4 and the last three compounds of group *B* show definite changes in spectrum in the presence of formaldehyde. Group *C* compounds, FH_2 and N^{10}-formyl-FH_4, show little or no change in spectrum when formaldehyde is added. Group *C* and the last two compounds of group *B* are relatively stable to oxygen and when kept in aqueous solution under air their spectra changed little (group *B*) or not at all (group *C*) over a period of several hours. Other hydropteridines can be protected from oxidative degradation by sulphydryl compounds, the most efficient of which is 2,3-dimercaptopropanol. This is considerably superior to mercaptoethanol and to mercaptoacetic acid; at a concentration of 5×10^{-3} *M* it stabilizes FH_4 (5×10^{-5} *M*) for many hours, and a concentration of 5×10^{-4} *M* is sufficient to stabilize FH_4 for spectrophotometric measurements.

Representative data for spectra shown by FH_4 in the presence of 2,3-dimercaptopropanol at *p*H 7 are shown in Table 2. The higher the initial formaldehyde concentration the greater was the value of the molecular extinction observed, until a maximum value of 32,000 was obtained in the presence of 10^{-3} *M* formaldehyde. There was also a slight shift in the wave-length of the absorption maximum, from 298 mμ in absence of formaldehyde to 294 mμ in the presence of 10^{-3} *M* formaldehyde. No evidence was obtained for the formation of complexes with absorption maxima at 290–293 mμ, as recently claimed[4].

The variation in the wave-length of the absorption maximum and in the extinction coefficient with formaldehyde concentration is believed to be due to the reversibility of the reaction of FH_4 with formaldehyde, rather than to the formation of a series of different complexes[4]. Evidence for this conclusion was obtained by studying the effect of bisulphite on the spectrum of FH_4. The spectrum of FH_4 (5×10^{-5} *M*) in the presence of phosphate buffer *p*H 7 (10^{-1} *M*) and 2,3-dimercaptopropanol (10^{-3} *M*) did not change at an appreciable rate on addition of sodium bisulphite (final concentration $3{\cdot}3 \times 10^{-4}$ *M*). If formaldehyde ($1{\cdot}5 \times 10^{-4}$ *M*) was first added to the solution of FH_4 and the reaction allowed to proceed to equilibrium as shown by the spectrum change, addition of sodium bisulphite then produced a rapid reversal of the spectrum change. This may be interpreted as being due to the dissociation of methylene-FH_4 as a result of the reaction of formaldehyde with bisulphite. Nine extinction values for FH_4 solutions (5×10^{-5} *M*) equilibrated with various concentrations of formaldehyde have been used to calculate the dissociation constant of the complex. A value of $4{\cdot}79 \pm 0{\cdot}30 \times 10^{-5}$ *M* was obtained at *p*H 7·2.

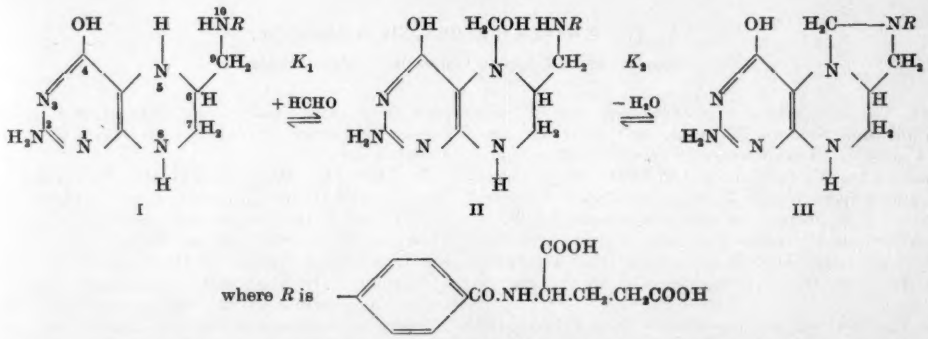
As expected, the time for attainment of equilibrium was inversely proportional to the initial concentration of formaldehyde; in agreement with the results of rate experiments reported above, spectrophotometric measurements showed that equilibrium was estab-

lished between FH_4 (5×10^{-5} *M*) and formaldehyde ($6{\cdot}67 \times 10^{-5}$ *M*) in about 10 min. Reaction in presence of 10^{-3} *M* formaldehyde was too rapid to measure.

Determination of the dissociation constant for the complex formed by FH_4 and formaldehyde in presence of 5×10^{-4} *M* 2,3-dimercaptopropanol gave the value $5{\cdot}12 \pm 0{\cdot}16$. The agreement between this value and that obtained in presence of 10^{-3} *M* 2,3-dimercaptopropanol indicates that at these levels 2,3-dimercaptopropanol does not bind significant amounts of formaldehyde. In the presence of concentrations of 2,3-dimercaptopropanol greater than 10^{-3} *M*, however, the values obtained for the dissociation constant were high and inconsistent. This is believed to be due to the fact that 2,3-dimercaptopropanol, like other sulphydryl compounds, reacts with formaldehyde and forms a complex with a high dissociation constant, so that significant amounts of formaldehyde are bound only at relatively high concentrations of 2,3-dimercaptopropanol. Evidence that FH_4 and formaldehyde react to form the same final product in the presence of 2,3-dimercaptopropanol as in its absence was found in the fact that 10^{-3} *M* 2,3-dimercaptopropanol did not alter the spectrum change occurring when 10^{-2} *M* formaldehyde was added to a solution of FH_4 at *p*H 7.

The failure of others to detect a non-enzymic reaction between dilute solutions of FH_4 and formaldehyde[4] may be due to the use of high concentrations of 2-mercaptoethanol (10^{-2} *M*), and this may also account for some other discrepancies. In any event, it has been found in this work that 2-mercaptoethanol (Eastman Kodak, at least 92 per cent in sulphydryl form) was ineffective compared with 2,3-dimercaptopropanol in protecting FH_4 from oxidation.

The following scheme is consistent with the results reported above:



where the overall equilibrium constant, *K*, is $2 \times 10^4\ M^{-1}$. Since N^{10} binds formaldehyde very weakly compared with N^5 (Table 1), II probably occurs as an intermediate in the formation and dissociation of III. By analogy with compounds of group *B* in Table 1, the dissociation constant of II may be expected to be about 0·03 *M*, so that K_1 = approx. 30 M^{-1} and $K_2 = K/K_1 = 667$. Hence at equilibrium methyleneFH$_4$ exceeds hydroxymethylFH$_4$ by a factor of about 700.

Addition of glycine and serine transhydroxymethylase to a solution of methyleneFH$_4$ resulting from equilibration of FH_4 (5×10^{-5} *M*) with formaldehyde ($1{\cdot}5 \times 10^{-4}$ *M*) in presence of 2,3-dimercaptopropanol (10^{-3} *M*) at *p*H 7·2 caused a change of the spectrum from that of methyleneFH$_4$ to that of a mixture of methyleneFH$_4$ and FH_4. At high glycine concentrations approximately 50 per cent of the methyleneFH$_4$ was converted to FH_4, resulting in the same spectrum as that obtained by adding sufficient formaldehyde to FH_4 to produce 50 per cent conversion to methyleneFH$_4$. As synthetic FH_4 and hence methyleneFH$_4$ are racemates due to the asymmetric centre introduced at C^6 during hydrogenation of folic acid, it appears likely that transhydroxymethylase catalyses a reaction with only one of the optical isomers. Neither enzyme nor glycine alone changed the spectrum of methyleneFH$_4$.

When L-serine was added to FH_4 (5×10^{-5} *M*) stabilized by 2,3-dimercaptopropanol (10^{-3} *M*) at *p*H 7·2 (phosphate buffer, 0·1 *M*) no change occurred. Subsequent addition of serine transhydroxymethylase caused a spectrum change corresponding to approximately 50 per cent conversion of FH_4 to methyleneFH$_4$. Even at high concentrations of L-serine the reaction did not proceed further than 50 per cent, presumably because the enzyme again catalysed reaction with only one isomer of the synthetic FH_4. Neither enzyme alone, nor enzyme together with D-serine, caused the spectrum change. The spectrum obtained when FH_4 was equilibrated with excess L-serine and enzyme was the same as that produced when sufficient formaldehyde was added to FH_4 to convert 50 per cent to methyleneFH$_4$. When excess formaldehyde was added to FH_4 which had been first equilibrated with L-serine and enzyme, the final spectrum had the same $\lambda_{max.}$ and extinction coefficient as that resulting from addition of excess formaldehyde to FH_4 alone.

Isolation of ethanol-insoluble barium salts from larger-scale incubations of DL-serine, enzyme and FH_4 gave a product with a spectrum in 0·1 *N* sodium hydroxide similar to that of methyleneFH$_4$. When the molecular extinction of the product was determined, however, it was found to be only about half that of methyleneFH$_4$; this is believed to be due to the rapid decomposition during isolation of the unreacted isomer of FH_4 giving rise to contaminating products with little absorption at 298 mμ. The material was active as coenzyme for enzymic synthesis of serine but decomposed in solution to an inactive product. The decomposition was accelerated by shaking in air or oxygen, by increase in temperature and by dilution. Under hydrogen, decomposition was negligible and catalytic hydrogenation restored some coenzyme activity to the decomposition products. The decomposition, like the decomposition of synthetic methyleneFH$_4$, was dependent on *p*H,

being fastest at about *p*H 5 and negligible at *p*H 13. This increased stability at higher *p*H seems to be due to the ionization of the 4-hydroxy group, since the effect becomes marked in the *p*H-range in which this group dissociates.

These results indicate that the only difference between synthetic methyleneFH$_4$ and the product of the enzymic reaction of L-serine and FH$_4$ is that synthetic methyleneFH$_4$ is a racemate, whereas the enzymic product is a single stereoisomer. No evidence was found that the non-enzymic reaction of formaldehyde and synthetic FH$_4$ produced any material of a different chemical nature from that of the enzymic intermediate. Spectrophotometric studies indicated that in the reaction:

$$\text{Glycine} + \text{methyleneFH}_4 \rightleftharpoons \text{serine} + \text{FH}_4$$

the equilibrium lies to the left, the constant being about 0·3. Although it has been assumed that it is methyleneFH$_4$ which reacts enzymically, the data are also consistent with N^5-hydroxymethylFH$_4$ (in rapid equilibrium with methyleneFH$_4$), being the actual participant in the reaction. The coenzyme activity of FH$_2$ may be due to the contamination of FH$_2$ preparations by FH$_4$. If, however, FH$_2$ is indeed a coenzyme and if it reacts with formaldehyde to form only N^5-hydroxymethylFH$_2$ as the value of the dissociation constant seems to imply, then N^5-hydroxymethylFH$_2$ is capable of reaction with glycine in presence of serine transhydroxymethylase, without mediation of a methylene-bridged compound. By analogy this would suggest that N^5-hydroxymethylFH$_4$ rather than methyleneFH$_4$ is the substrate for serine transhydroxymethylase; furthermore, a simple reaction mechanism is possible if this is the case. Enzymic dehydrogenation of the formaldehyde-FH$_4$ complex to N^{10}-formylFH$_4$ via N^5,N^{10}-metheneFH$_4$ (anhydroleucovorin) is more easily conceived as involving methyleneFH$_4$ as substrate[7].

In the above discussion no mention has been made of the fact that glycine and serine react in the form of Schiff's bases of pyridoxal phosphate. In the spectrophotometric experiments reported here no pyridoxal phosphate was added, but previous evidence indicates that it is firmly bound to serine transhydroxymethylase. It may be assumed that, prior to their interconversion, serine and glycine react with bound pyridoxal phosphate to form Schiff's bases.

I should like to express my indebtedness to Dr. D. J. Brown for generous gifts of pteridines, to Mr. J. McKeough for skilled technical assistance, and to Prof. A. H. Ennor and other members of this Department for helpful advice and criticism.

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SOME NEW VERTEBRATE FOSSILS FROM THE PANCHET SERIES OF WEST BENGAL

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THE Panchet series of rocks form part of the Gondwana System of India, and their age has been a subject of controversy ever since they were first named by W. T. Blanford[1] in 1861. Suggestions have ranged from Upper Permian to Upper Triassic, inclusive. The purpose of this communication is to make a preliminary announcement of some new discoveries of vertebrate fossils from the Panchets which do much to solve the question of the age of these rocks.

The Panchet series occur chiefly in the Raniganj coalfield of West Bengal, where they form a cover to part of the coal-bearing Damudas. The succession of Gondwana rocks in the Raniganj coalfield is:

Supra-Panchets	
Panchet series	
Damudas	Raniganj measures
	Ironstone shales
	Barakar measures
Talchir series	

All these rocks were formed under continental conditions during late Palæozoic and Mesozoic times. They accumulated in a depression or valley in a landscale carved out of Archæan rocks, and are themselves largely erosion debris which was derived from neighbouring hilly areas made up of Archæans. The upper part of the Panchet series consists mainly of sandstones with subordinate shales, while the lower part is mainly shales with subordinate sandstone bands. No trace of coal has ever been found in the Panchet series.

In 1860 Dr. Blanford and Mr. Tween discovered some fossils in the Panchet series. Plant remains were found in the lowest beds and were described by Feistmantel[2] in 1880. Of the eleven species described, seven are also found in the underlying Damuda formations. Isolated and fragmentary bones, often rolled and water-worn, were discovered in conglomeratic sandstones in the upper part of the Panchets, where these rocks crop out in the bed of the River Damuda. These bones, usually teeth, fragments of jaws, vertebræ and limb bones, were described by Huxley[3], and later collections of similar material were described by Lydekker[4]. These authors identified a fauna consisting chiefly of labyrinthodonts and dicynodonts. A few years ago, Dr. M. R. Sahni, palæontologist to the Geological Survey of India, asked a field officer, Mr. S. N. Puri, to make a further collection from the conglomeratic Upper Panchet sandstones. Mr. Puri found fossiliferous outcrops at a number of places in the southern part of the coalfield, made an excellent map of these localities, and brought back a collection which included one good roof of a labyrinthodont skull, as well as a large number of isolated bones and fragments. The

labyrinthodont is being described by Prof. F. von Huene and Dr. Sahni.

Permo–Triassic labyrinthodonts are only rarely of use in correlation and dating. Some dicynodonts are very useful horizon-markers, but since this group has a considerable uniformity of general structure, while varying a great deal in detailed morphology, it is necessary to have good specimens before a proper assessment of affinity can be made. Dicynodonts are locally common in the Permian *Tapinocephalus* zone of South Africa, in the next, *Endothiodon*, zone they are fairly abundant, and they are exceedingly common and varied in the succeeding *Cistecephalus* zone. In the *Lystrosaurus* zone, though individuals are often abundant, almost all belong to the genus which gives its name to the zone. The genus is not found outside this zone and is therefore an excellent zone fossil. During the rest of the Trias, dicynodonts are restricted to a few genera of large size. Thus, the presence of dicynodonts in the Panchet series does not provide a means of dating these rocks without the more detailed knowledge of these fossils which only good specimens can provide.

In the re-survey of the Raniganj coalfield made in 1925–28 [5], some fish scales were found at a single locality in the lower Panchet shales. Among these, Dr. E. I. White identified a scale of *Amblypterus*, and this lends a distinctly Palæozoic aspect to the lower part of the Panchets, as does the character of the flora.

In the autumn of 1957 I went to India as the guest of the Indian Statistical Institute, at the invitation of the director, Prof. P. C. Mahalanobis. At the beginning of December I visited the Raniganj coalfield as part of a programme of field-work which had as its main object the attempt to discover further vertebrate fossils in various formations of the Gondwana System. The rather fragmentary remains found in some of the Gondwana formations, mainly during the past century and usually by amateurs, suggested that the Gondwana System might be potentially as rich in fossil vertebrates as the famous Karroo of South Africa, and apart from the evolutionary interest of any discoveries which could be made, these would also provide a means of correlating and dating the Gondwana formations. Hitherto, correlations have mainly been made on floral evidence, which is not a very satisfactory tool, but which has had to be used in default of anything else.

The field-work on the Panchets of the Raniganj coalfield was carried out as a collaboration between the Indian Statistical Institute and the Geological Survey of India. Three junior Survey officers, Mr. C. Tripathi, Mr. P. P. Satsangi and Mr. S. T. Rajurka, and two palæontological research workers at the Indian Statistical Institute, Dr. S. L. Jain and Mr. T. K. R. Chowdhury, accompanied me into the field. We found that, in the upper part of the Panchet series, conglomeratic sandstone was very fossiliferous in places, but though part of an amphibian skull roof and a few good specimens of individual bones and jaws were obtained, many of the fossils were fragmentary and no associated skeletons were ever found. The reason for this is plain from an examination of the sandstones. They are all highly false-bedded rocks, and in places even contorted. They evidently represent a large delta tip-heap, into which sand, pebbles and animal bones were swept by a river and its tributaries. The sediment sometimes piled up so fast that it became unstable and slumped a little way down the growing delta front. The shales of the lower part of the Panchet series seemed to form lenses of various sizes, the formation of which could be envisaged as due to the gradual silting up of pools and lakes. Under such conditions, land animals dying in or near to the pools would be more likely to suffer burial without dismemberment. We therefore began to search the shales in the lower part of the Panchets, and Mr. P. P. Satsangi was the first to discover in them the skeleton and skull of a dicynodont. The skull could immediately be identified as that of a species of *Lystrosaurus*. Five skulls and some more skeletal remains of *Lystrosaurus* were found, but no other tetrapods so far.

The discovery of a number of good specimens of *Lystrosaurus* in the Panchets allows the immediate correlation of the series with a zone of the Karroo succession in South Africa. The zones of the South African succession, and their dicynodont faunas, are :

Beaufort series :		
Cynognathus zone	*Kannemeyeria*	Lower Triassic
Procolophon zone		
Lystrosaurus zone	*Lystrosaurus* and *Myosaurus*	
Cistecephalus zone	*Dicynodon*, *Cistecephalus*, and other genera with 195 spp.	
Endothiodon zone	*Dicynodon*, *Endothiodon*, and other genera with 27 spp.	Upper Permian
Tapinocephalus zone	*Dicynodon* and other genera with 8 spp.	

Since *Lystrosaurus* has also been discovered in Sinkiang[6], the new discovery in the Indian Panchets is of interest as going some way towards providing a geographical link between Sinkiang and South Africa in the distribution of the genus in early Triassic times.

Only one other associated skeleton of a fossil tetrapod has ever been found in the entire Gondwana System. The previous discovery was made almost a hundred years ago by an Army officer, Major Gowan, who found the skeleton and skull of the labyrinthodont *Gondwanasaurus bijoriensis* at the crossing of a stream by a bullock-cart track some miles south-west of Pachmari. The new discoveries raised hopes about the possibilities in other formations of the Gondwana System, and these hopes have already been realized in field-work done in other areas by me, in collaboration with Dr. Jain and Mr. Chowdhury. The fossils discovered are still under investigation, but comprise skeletons and skulls instead of the fragments previously known. The Gondwana formations can evidently be regarded as a very hopeful source of fossil vertebrate material, and certain formations provide the only possibility of obtaining a continental fauna of Lower to Middle Jurassic age anywhere in the world.

A rather more detailed account of the work done on the Panchets of West Bengal, with a preliminary discussion of the new fossil material, will appear elsewhere, and a detailed description of the new *Lystrosaurus* specimens will be undertaken by Tripathi and Satsangi at the Geological Survey of India.

It is a pleasure to thank Prof. Mahalanobis for the invitation and facilities which made my work in India possible. I am grateful to many members of the Indian Statistical Institute for their help. I should also like to thank Mr. V. P. Sondhi, director of the Geological Survey of India, for much help and friendly co-operation, and Mr. K. K. Datta for facilities in the field.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Stabilization of Water Mists

The stability of a water mist formed in an atmosphere that is not fully saturated is severely affected by droplet evaporation. Thus a water-drop 10μ in radius suspended in air at 20° C. and 80 per cent relative humidity can be shown to have a life of only 2·4 sec. Richardson[1] describes experiments in which no water-drop of radius less than 200μ, dropped from the top of a 40-m. tower, reached the bottom.

The possibility of reducing the coefficient of evaporation of a plane water surface from 4×10^{-2} to 6×10^{-6} by coating it with a monomolecular layer of a long-chain fatty acid has been demonstrated[2], and reductions in the rate of evaporation of the order of 50 per cent have been obtained by means of monolayers of cetyl-stearyl alcohol[3]. Bradley[4] pointed out that, with droplets of Stokesian or smaller size, a corresponding reduction in the evaporation coefficient could be expected to result in a very much greater reduction of the rate of evaporation than with a plane surface. This was shown to follow from a simplified form of Fuchs's[5] equation of droplet evaporation :

$$\frac{dm}{dt} = \frac{-4\pi a w c_0}{1 + (D/a\nu\alpha)}$$

in which dm/dt is the rate of evaporation of the droplet, a its radius, w the mass of a vapour molecule, α the evaporation coefficient, c_0 the saturation concentration of vapour in air, D its diffusion coefficient, and $\nu = \sqrt{(kT/2\pi w)}$, where T is the absolute temperature.

The present communication describes an attempt at producing a water mist each drop of which is coated with a monolayer. This was done by dispersing in the water a mixture of almost equal parts of cetyl and stearyl alcohol in a concentration of 0·2 per cent by weight, using as a dispersing agent 0·1–0·2 per cent of a compound of "fully hardened sperm alcohol and 15 molecules (average) of ethylene oxide". The dispersion is stable and can be atomized. At the low mean droplet radii of the aerosol so generated (mean surface radius 7·5μ) this overall concentration proved sufficient to coat the droplets. This is because the rate of diffusion of water into the air at the droplet surface is about 10^4 times that of the dispersed alcohol into the droplet interior ; once evaporation starts, monolayers of high surface pressure may be expected to form on the surfaces.

To test the efficacy of the monolayers the dispersion was atomized by means of a compressed-air nozzle and introduced into the top of a vertical tube, 1 ft. in diameter and 15 ft. high, the aerosol being sampled during its descent at various levels inside the tube. The vertical tube was kept at a temperature of 28·3° C. and the humidity varied over a wide range. Counts made of the various samples gave droplet size distributions which enabled the rate of evaporation to be calculated as a function of relative humidity. The experiments were repeated with water alone. Fig. 1 shows the variation with relative humidity of the initial radius of droplets, both water and dispersion, that just fall through 12 ft. in these conditions before completely evaporating.

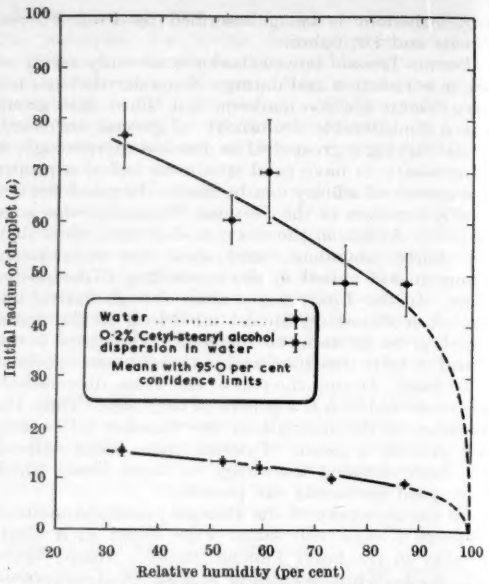
Initial radius of droplet (μ)
Relative humidity (per cent)
Water
0·2% Cetyl-stearyl alcohol dispersion in water
Means with 95·0 per cent confidence limits

Fig. 1. Effect of humidity on the initial radius of a droplet that falls 357 cm. before completely evaporating. (Crown copyright, S.M.R.E.)

Measurement of the evaporation coefficient of the dispersion gave a minimum value of $1·5 \times 10^{-5}$ at high concentrations. Substituting this value in Fuchs's equation, it was found that the latter predicted the rate of evaporation of the dispersion droplets and its variation with relative humidity, within the size-range used, with some accuracy. The equation could thus be used to calculate the total life of the droplets shown in Table 1.

Table 1. Life of Droplet at 20° C. and 80 per cent Relative Humidity

Radius of droplet (microns)	Water (sec.)	Dispersion (sec.)
5	0·64	656
10	2·35	1,314

A considerable increase in the life of a droplet and, hence, stability of mist is thus obtained. In more recent experiments it was found that concentrations of 0·1 per cent of alcohols and of dispersing agent gave results that did not differ significantly from those with 0·2 per cent of these agents.

A more detailed paper is to be published in due course. We wish to thank Dr. T. G. Jones, Research Department, Unilever, Ltd., for suggesting and preparing the dispersing agent and the Ministry of Power for permission to publish this communication.

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Diffraction Anomaly in Polarizing Microscopes

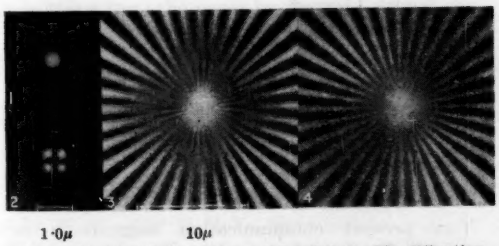
THE image quality of the polarizing microscope has never been critically examined, perhaps because the instrument was used primarily for determining optical constants of crystals and fibres, rather than for studying fine details of the object. We have recently re-examined its reliability and find that unless the rotation at the lens surfaces is rectified, the unit diffraction pattern is not an Airy disk but a four-leaf-clover pattern, and that the resolution and contrast may be spurious.

In a conventional polarizing microscope the field between crossed polarizers illuminated by a bright source is never completely dark. If the microscope is equipped with lenses completely free from strain birefringence a polarization cross is observed at the back aperture of the objective lens. The light in this cross is introduced almost exclusively by rotation of the plane of polarization at the oblique interfaces between the polarizer and the analyser[1,2]. The rotation is a consequence of differential transmittance of the vectors polarized parallel and perpendicular to the planes of incidence and may reach 6 deg. or more at the edge of the aperture. This not only lowers the extinction of the polarizing microscope at high numerical apertures, but also modifies the aperture function of the system even when the condenser diaphragm is closed. As a result, the diffraction image of a pin-hole between crossed polarizers is no longer a regular Airy disk (Fig. 1) but a clover-leaf pattern possessing a dark centre and a dark cross (Fig. 2). Its intensity is expressed by :

$$I \simeq \sin 2\theta \, J_3(r)/r \qquad (1)$$

where θ and r are polar co-ordinates in the image plane (θ is measured from the plane of polarization of the polarizer and r is measured in diffraction units) and $J_3(r)$ is a Bessel function of the third order.

Densitometry of photographs of sub-resolution pinholes taken through a special strain-free polarizing microscope agrees well with the distribution of intensity calculated from this formula. The special polarizing microscope used for this work was designed jointly by one of us (S. I.) and the American Optical Co. and was constructed at the University of Rochester with generous support from the former. The distribution of intensity along $\theta = \pm \pi/2$ (Fig. 5) shows that the radius of the central maximum in the clover-leaf pattern coincides approximately with the first minimum of the Airy disk. The ratio of the intensity of the central to that of the first diffraction maxima is 10 : 1 in the clover leaf as opposed to 50 : 1 in the Airy disk.



1·0μ 10μ

Fig. 1. Airy disk in the absence of a polarizer. The diffraction pattern was obtained by optically reducing a pinhole 20μ in diameter located in front of the lamp to 0·2μ and then re-magnifying. A pair of identical strain-free 97 × oil-immersion objectives with 1·25 numerical aperture was used. The image produced by this system is identical with the image of a 0·2-μ pinhole located at the object space, except that the lens errors are doubled

Fig. 2. As for Fig. 1, but between crossed polarizers. Scale for Figs. 1 and 2, 1·0μ

Fig. 3. Image of a Siemens's test chart between crossed polarizers. Except for the Siemens's star which replaced the pinhole, system identical with that of Fig. 2. Notice reversal of contrast and spurious resolution. Scale for Figs. 3 and 4, 10μ

Fig. 4. Image of same test-chart as in Fig. 3, between crossed polarizers but viewed through the same objectives after they were rectified. The diffraction anomaly has disappeared

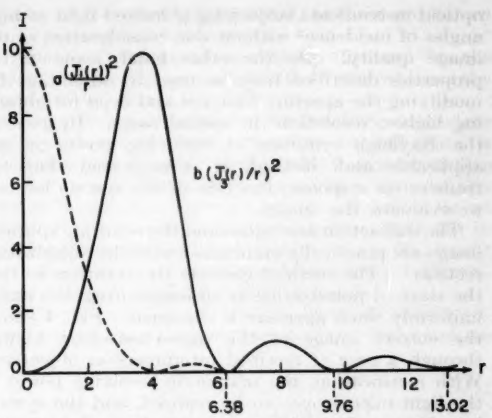


Fig. 5. Intensities (I) of the diffraction image of an unresolved pinhole calculated along the radius (r in diffraction units) at 45° to the plane of polarization. Broken line, Airy diffraction pattern in non-polarized light, or in polarized light with rectified optics. Solid line, with non-rectified optics between crossed polarizers. The curves have been normalized to make the central maxima equal. Microdensitometer tracings of Figs. 1 and 2 agree with the calculated curve to within a few per cent

When, on the pinhole, a uniaxial crystal is superimposed with its optic axis parallel to the axis of the microscope (Z-cut), the diffraction image of the pinhole between crossed polarizers is again expressed by equation (1) even in the absence of rotation. With parallel polarizers a diffraction image similar to that in an astigmatic system is formed by the extraordinary rays, superimposed on the Airy disk formed by the ordinary rays. These are also the diffraction images of pinholes formed by catadioptric (reflecting) polarizing microscopes without any crystals.

When a crystal is introduced with its axis normal to the microscope axis (X-cut), a highly astigmatic diffraction pattern identical with those reported by Nienhuis for conventional astigmatism is superimposed on the Airy disk. Theoretical formulæ for all these diffraction patterns, except for the X-cut crystal, were calculated by one of us (H. K.); they are reported in ref. 3 together with their experimental verifications.

The effect of anomalous diffraction on a periodic absorbing object was determined by observing a black-and-white test chart through a pair of oil-immersion lenses showing a medium degree of rotation. As shown in Fig. 3, contrast reversal and spurious resolution are observed to varying degrees at different orientation of the periodic object.

These diffraction anomalies clearly indicate the danger of using polarizing microscopes or other

optical instruments employing polarized light at high angles of incidence[2] without due consideration of the image quality. On the other hand, some of the properties described may be used to advantage for modifying the aperture function and even for obtaining higher 'resolution' in special cases. In general, the Rayleigh criterion of resolving power is not applicable and, instead, it is suggested that the transfer (or response) function of the system be used to evaluate the image.

The diffraction anomalies and the resulting spurious image are practically eliminated with the polarization rectifier[2]. The rectifier corrects the rotation so that the state of polarization is no longer irregular, and a uniformly dark aperture is obtained. Fig. 4 shows the correct image of the same test-chart viewed through a pair of rectified oil-immersion objectives. With rectification, the maximum resolving power of the light microscope can be realized, and the system has been utilized for exact studies of biological objects possessing birefringence down to a fraction of an angstrom unit.

This research was supported in part by grant (*C*-3002-*C*) from the National Institutes of Health, U.S. Public Health Service, awarded to Shinya Inoué, a National Science Foundation grant awarded to Dr. M. Parker Givens, Institute of Optics, University of Rochester, and by the American Optical Company.

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Mosaic Structure of Photographic Emulsion Crystals

Crystal imperfections play an important part in present studies of the formation of the photographic latent image. In large silver bromide crystals it has been shown[1] that silver prints out along individual dislocation lines. Little direct evidence has yet been given on defects within the small grains of photographic emulsions, since neither light microscopy nor electron microscopy has yet proved effective in this field.

It was found by a convergent beam X-ray analysis[2] and by an X-ray microbeam diffraction method[3] that there exist in the grains of some commercial photographic emulsions distinct angular misalignments and sub-structures. In recent studies of X-ray microbeam transmission photographs using a Hilger 'Microfocus Unit' we have now been able to obtain separately resolved structures within the diffraction spots from individual emulsion grains. In some of these spots up to six individual subdivisions can be detected (see Fig. 1*a* and *b*, each of which shows enlargements (×120) of a diffraction spot). Such high-resolution spots were obtained with X-ray tube focal areas of dimensions 4 × 40μ and 100 × 140μ with lead glass capillaries of 10μ diameter as collimators for the incident X-ray beam. As recording

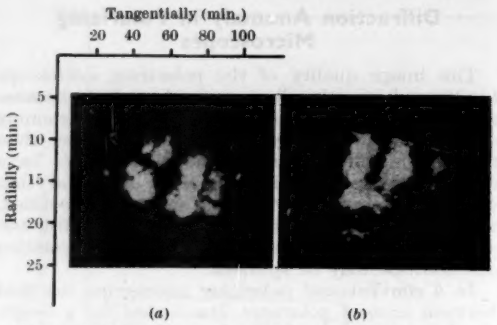

Fig. 1. Enlargements (× 120) of diffraction spots taken from a photographic emulsion having grains with a mean diameter of 1μ (*a*) and 1·5μ (*b*). Each group of spots corresponds to a diffraction image of one grain. The scales correspond to the angular displacement of planes in radial and tangential directions

material Kodak 'Crystallex' X-ray film was used. Experiments were carried out to show that the grains themselves, and neither the intensity distribution of the focal spot nor the structure of the paper of the envelope of the recording film, is responsible for the effect. This evidence is also supported by the fact that within the same type of photographic emulsion grains different types of characteristic structures of spots can be distinguished within the spotty powder ring. On the other hand, certain other emulsion grains under the same exposure conditions show diffuse diffraction spots (without any sub-divisions) and this effect is probably due to broadening of small crystallites size. (*Note added in proof:* We now have direct evidence that this explanation is correct.)

From considerations of the divergence of the X-ray beam, the natural spread of wave-lengths, and the separation of the $K\alpha_1$ and $K\alpha_2$ wave-lengths, it is concluded that the detail within diffraction spots reveals the mosaic structure of the grains. From measurements of the distances between nearest structure elements within diffraction spots it is found that angular misalignments of 3′–4′ between planes are resolved.

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Neutron–Proton Interaction

The present communication suggests a new approach to the proton–neutron interaction and the deuteron problem. We have been able to calculate successfully the binding energy of the deuteron by the suggested interaction. The approach is phenomenological in that the structure of the nucleons has not been taken into account.

It is proposed that the interaction between the nucleons is magnetic. First let us consider a model based on the old quantum theory. Let μ_p and μ_n represent the magnetic moments of the proton (positive) and neutron (negative) respectively, and let r be the distance between them. Then the

minimum potential energy in the attractive case is given by :

$$W = \frac{2\mu_p\mu_n}{r^3} \quad (1)$$

The spin of the deuteron is 1, which suggests a parallel alignment of the neutron and proton spins, and no orbital motion of the two nucleons about their common centre of mass.

The value of r has to be determined by quantum conditions. Turning to the quantization of length, if M_r be the reduced mass of the system, a highly suggestive fundamental length is $h/2\pi M_r c$.

Then the distance in the nth state is given by :

$$r_n = \frac{nh}{2\pi M_r c} \quad (2)$$

This expression can be justified in other ways also :

(i) In the Bohr atom model, the expression for the radius can be written :

$$r_n = \frac{n\hbar}{M_r c} \cdot \frac{c}{v} \quad (3)$$

Under the condition $v \to c$,

$$r_n = \frac{n\hbar}{M_r c}$$

which is the same as (2).

(ii) The Bohr expression for the radius is :

$$r_n = \frac{n^2\hbar}{M_r c} \cdot \frac{1}{\alpha} \quad (4)$$

where α is the fine structure constant (1/137·04). Current nuclear theories suggest that for the nucleus the corresponding constant is approximately 1. If we assume that $\alpha = 1$ for the nucleus :

$$r_n = \frac{n^2\hbar}{M_r c} \quad (5)$$

which is the same as (2) except for the power of n.

Substituting the value of r_n in equation (1), we get :

$$W = \frac{2\mu_p\mu_n M_r^3 c^3}{n^3\hbar^3} \quad (6)$$

In the following, the values of the magnetic moments and masses of neutron and proton have been taken from the paper by Shapiro[1].

For the ground-state :

$$W = -2\left(\frac{2{\cdot}792743e\hbar}{2M_p c}\right)\left(\frac{1{\cdot}913138e\hbar}{2M_p c}\right)\frac{M_r^3c^3}{\hbar^3} \quad (7)$$

First we deduce an approximate expression. Putting $M_r \approx M_p/2$, expression (7) becomes :

$$W = -(2{\cdot}792743)(1{\cdot}913138)\left(\frac{M_p c^2}{16}\right)\frac{e^2}{c\hbar} \quad (8)$$

With $M_p c^2 = 938{\cdot}21$ MeV., this simplifies to :

$$W = -2{\cdot}286 \text{ MeV.} \quad (9)$$

Next we calculate W by taking the exact value of M_r. As $M_p c^2 = 938{\cdot}21$ MeV. and $M_n c^2 = 939{\cdot}51$ MeV., $M_r c^2 = 469{\cdot}43$ MeV., and equation (6) gives :

$$W = -2{\cdot}291 \text{ MeV.} \quad (10)$$

This value is in good agreement with the observed binding energy 2·226 (±0·002) MeV. (Wapstra[2]). However, the discrepancy of 0·065 MeV. is well outside the limits of experimental error. Further, it cannot be explained as due to possible errors in the values of the constants involved, as these are known to a high degree of accuracy.

Either of the equations (2) or (5) may be the correct one. By equation (2), $W \propto 1/n^3$, and by equation (5), $W \propto 1/n^6$.

Using the experimental value for the ground-state energy of the deuteron, the first excited state is indicated at 0·278 MeV. or 0·035 MeV. (corresponding to the two possibilities). No excited state of the deuteron has been reported so far. Should it be at 0·035 MeV., it could have been easily missed due to the fact that the transition energy ($W_2 - W_1$) would be very close to the disintegration energy. Experiments on this point are highly desirable.

Next we consider the wave mechanical treatment. The present suggestion defines a tensor force and we can put :

$$V = -S_{12}J(r) \quad (11)$$

where $$J(r) = -\frac{\mu_p\mu_n}{r^3}$$

and $$S_{12} = \frac{3(\sigma_1.r)(\sigma_2.r)}{r^2} - \sigma_1.\sigma_2$$

where σ_1 and σ_2 are the Pauli spin operators for the proton and neutron respectively.

Usually a mixture of central and tensor potentials is employed[3]. Christian and Noyes[4] have used a pure tensor force in the investigation of p–p scattering.

Equation (11) is also a pure tensor force. But of course one can speak of an 'equivalent central force' (Christian and Hart, ref. 3).

The states $^3S_1$ and $^3D_1$ would be coupled for the present potential, and, following Rarita and Schwinger[3], it is seen that the radial wave functions for the $^3S_1$ and $^3D_1$ states must satisfy the simultaneous equations :

$$\frac{d^2u}{dr^2} + \lambda E u - 8^{1/2}\cdot\frac{\lambda\beta}{r^3}w = 0 \quad (12a)$$

$$\frac{d^2w}{dr^2} + \left[\lambda E + \frac{2\lambda\beta}{r^3} - \frac{6}{r^2}\right]w - 8^{1/2}\cdot\frac{\lambda\beta}{r^3}u = 0 \quad (12b)$$

where $$\lambda = 2M_r/\hbar^2$$

and $$\beta = \mu_p\mu_n$$

These equations suffer from the well-known difficulties associated with r^{-3} singularity. Perhaps a 'cut-off' device[5] will have to be used with 'cut-off' at $\hbar/M_r c$.

In view of the fact that in the case of the hydrogen atom results on the basis of old quantum theory and wave mechanics are nearly the same, it may be that for the deuteron also the situation is not very different.

The quadrupole moment of the deuteron is expected to be of the order of r_1^2. With the value of r_1 given by equation (2):

$$Q \sim r_1^2 = 1{\cdot}764 \times 10^{-27} \text{ cm.}^2$$

This may be compared with the experimental value

$$Q = +2{\cdot}73 \times 10^{-27} \text{ cm.}^2$$

There is also the possibility that the interaction may be a combination of a central force and the magnetic tensor force, but the tensor force alone may be responsible for the binding. It may be mentioned that interesting analogies between magnetostatics and the pseudo-scalar meson field have been drawn by Kahana and Coish[6].

Further details of the investigation are to be published later.

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An Artificial Aurora

In a recent communication[1] conclusive evidence has been presented for the artificial production of auroral phenomena by the detonation of a nuclear device in the upper atmosphere. The auroral display in question was observed at Apia Observatory, lat. 13° S., long. 171° W., and is considered to have been produced by a nuclear bomb exploded approximately one hundred miles above Johnston Island, lat. 17° N., long. 169° W.

The distance between Johnston Island and Apia is about 2,200 miles, and hence an explosion 100 miles above Johnston Island could not be seen from the upper atmosphere over Apia. Thus direct radiation from the explosion could scarcely be the cause of the observed aurora. On the other hand, as undoubtedly will have occurred to many people, if a nuclear explosion is produced high enough in the atmosphere, charged particles emitted as a result of this explosion could be guided along the lines of force of the Earth's magnetic field and returned to Earth at a point on the same geomagnetic longitude and opposite geomagnetic latitude. While there will be a small eastwards drift across the lines of force due to the vertical gradient of the Earth's field, it will be only of the order of 100 metres, the exact magnitude depending upon the angle of pitch of the particle's trajectory. Since the geomagnetic equator at a geographic longitude of 170° W. is situated at about 3° N., and the declination in this region is about 10° E., it can be seen that Johnston Island and a region to the north-west of Apia do approximately fulfil these conditions of lying on the same line of force.

In a nuclear explosion, electrons and charged ions will be produced. The electrons will have β-ray decay energies of up to a few million electron-volts and thus, neglecting electrostatic forces, will readily be able to escape from any residual matter above the point of detonation and, on their return to the atmosphere, be able to produce effects at relatively low altitudes. Therefore, it seems that these β-ray electrons can adequately explain the observed phenomena. The charged ions produced at the same time would appear in general not to have sufficient energy to enable them to escape from the region of the explosion.

The duration of the auroral display was between six and seven minutes. The transit time for β-rays between Johnston Island and Apia along a line of force would be only a few hundredths of a second, and for β-rays of lower energy moving in spirals around the lines of force with very small angles of pitch can scarcely exceed a few seconds. However, there appear to be at least two mechanisms operating which explain the long time-scale of the aurora. First, the average life-time of nuclei produced in nuclear explosions which decay by β-emission is of the order of minutes, and, secondly, large numbers of atoms in the upper atmosphere over Apia must have been excited to metastable states which decayed with appreciable life-times.

The demonstration of the possibility of producing aurora artificially at once suggests the great interest that would be attached to studying the effects of any high-altitude nuclear explosions in the auroral belt, or elsewhere at still higher altitudes. Such an experiment would represent the injection of particles into the region of high particle-density recently detected by Earth satellite observations[2] and would enable one to study the storage and propagation of charged particles in this region.

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Rate of Accumulation of Nickel in Atlantic Equatorial Deep-Sea Sediments and its Bearing on Possible Extra-Terrestrial Sources

In a recent communication, Pettersson[1] estimated the rate of accumulation of nickel on the Earth from extra-terrestrial sources on the basis of the nickel-bearing particles caught on filters located on the summits of two Hawaiian volcanoes. His value for the rate of accumulation of extra-terrestrial nickel is $6{\cdot}5 \times 10^{11}$ gm./yr. for the Earth as a whole. If the rate of accumulation is reasonably constant over the Earth's surface, then this figure corresponds to 33×10^{-6} gm. nickel/cm.^{2} of the Earth's surface/1,000 yr.

I have recently determined the rates of accumulation of nickel and other elements in a calcareous eupelagic Atlantic equatorial core (Lamont *A* 180–76), using emission spectrography and time estimates based on radiocarbon dates made on this and neighbouring cores.

In core *A* 180–76 there are three major climatic events recorded. The estimates of the duration of each climatic zone are from the paper by Broecker, Turekian and Heezen[2]. These estimates, together with the description of each zone and the calculated rates of accumulation of nickel, are given in Table 1.

Table 1

Zone	Interval (cm.)	Climate, description and duration	Average nickel content (p.p.m.)	Rate of accumulation of nickel (10^{-6} gm./cm.^{2}/1,000 yr.)
A	0–25	The most recent warm period commencing 11,000 yr. ago	13	22
B	30–260	The last major cold period (including an interstadial period) lasting about 60,000 yr.	17	49
C	265–410	The immediately preceding major warm period lasting about 80,000 yr.	13	18

The average of the rates of nickel accumulation for zones *B* and *C*, which are of about equal duration, is 33 × 10^{-6} gm./cm.²/1,000 yr., comparable to Pettersson's value for extra-terrestrial accumulation. However, this must not be construed to be a confirmation of the extra-terrestrial origin of the nickel on the sea floor. There must be a significant nickel contribution from terrestrial sources to the deep-sea since the rates of accumulation of other components, such as copper and lead, are high. If nickel follows the same pattern of supply to the sea as these elements, then a major part, if not all, of this nickel accumulated may be due to terrestrial supply. In addition, the rate of accumulation of nickel, as well as several other elements and the clay fraction, varies as a function of climate, again suggesting terrestrial control of supply. Of course, this may be a matter of redistribution in the sea rather than change in total supply. This can only be confirmed by more extensive regional determinations of accumulation-rates of deep-sea sediment components in the Atlantic.

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Thermogravimetric Investigations of Peat

THE differential thermal characteristics of peat, recently reported by Mitchell[1], show an interesting correlation with results obtained in thermogravimetric studies carried out in these laboratories.

The apparatus used was a 'Stanton' thermobalance with provision for controlled atmosphere. Peat from three different sources, previously dried to approximately 10 per cent water-content for use as fuel in our experimental gas turbine, was ground and passed through a 150-mesh sieve. A 1 gm. sample was placed in a platinum crucible in the thermobalance furnace and a stream of nitrogen passed through the furnace at a velocity of 40 l./hr. Continuous recording of the weight of the sample was carried out while a rate of heating of 4° C./min. was maintained. Automatic arresting of the balance at 5-min. intervals recorded the time-scale on the weight curve. Differential curves were prepared by plotting the rate of loss of weight in mgm./min. against temperature.

The three peats used in these experiments were obtained from (*a*) Gardrum moss near Falkirk, Scotland, (*b*) Lullymore, Co. Kildare, Eire, (*c*) Altnabraec, Caithness, Scotland.

Representative differential curves obtained for these three peats are shown in Fig. 1. In all cases there is an initial evolution of water vapour in the region of 100° C., the peak occurring at a slightly higher temperature with the peats from Lullymore and Altnabraec than that from Gardrum because of the higher water-soluble contents of these peats.

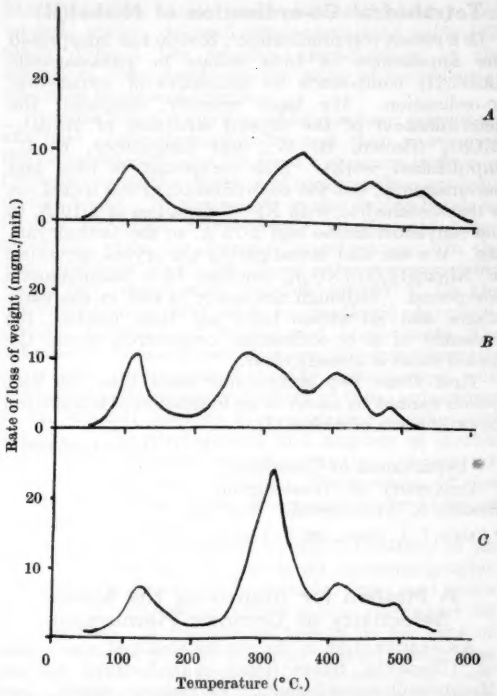

Fig. 1. Differential thermogravimetric curves of peat in nitrogen
A, Gardrum peat; *B*, Lullymore peat; *C*, Altnabraec peat

A subsequent release of volatile matter occurs in the 250–600° C. region and exhibits a main peak followed by two smaller peaks. Although the position of the peaks varies as much as 75° C. with differing peats, their relative position in each peat is remarkably constant.

The first two peaks show a close correspondence with the two-peak system reported by Mitchell[1] in complete combustion differential thermal analysis curves (Table 2). The two main exothermic differential thermal analysis peaks must therefore result from the combustion of volatiles released at about 300° C. and 400° C. as shown by the thermogravimetric studies.

Comparative thermogravimetric studies on peat and coal have proved to be of value in predicting the burning characteristics of these fuels, and in particular in determining the degree of pre-heating necessary to release volatiles and initiate combustion.

This report is related to work done through the agency of Messrs. Ruston and Hornsby, Ltd., on behalf of the Ministry of Power, with whose permission it is now published.

Table 1. PEAKS IN DIFFERENTIAL THERMOGRAVIMETRIC CURVES OF THREE PEATS

Sample	T_1	T_2	T_3	T_2–T_1	T_3–T_2
Gardrum	350	450	525	100	75° C.
Lullymore	275	400	480	125	80° C.
Altnabraec	320	420	500	100	80° C.

T_1, First peak; T_2, second peak; T_3, third peak

Table 2. PEAKS IN COMPLETE COMBUSTION DIFFERENTIAL THERMAL CURVES (MITCHELL, *loc. cit*)

Sample	T_1	T_2	T_3	T_2–T_1	T_3–T_2
Eriophorum peat	320	420	—	100	— ° C.
Calluna peat	300	380	420	80	140° C.

T_1, First peak; T_2, second peak; T_3, third peak.

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Tetrahedral Co-ordination of Nickel(II)

In a recent communication[1], Katzin has interpreted the appearance of blue colour in paramagnetic nickel(II) compounds as indicative of tetrahedral co-ordination. We have recently completed the determination of the crystal structure of $Ni(en)_2(NCS)_2$ (Brown, B. W., and Lingafelter, E. C., unpublished work). This compound is blue and paramagnetic, but the co-ordination of the nickel ion is transoctahedral, with Ni—N distances of 2·10 A. to the ethylenediamine and 2·15 A. to the *iso*thiocyanate. We are also investigating the crystal structure of $Ni(en)(H_2O)_4(NO_3)_2$, another blue paramagnetic compound. Although the study is still in the early stages and all atoms have not been located, the presence of a co-ordination octahedron about the nickel atom is already clear.

Thus these two compounds show that the blue colour cannot be taken as an indication of tetrahedral co-ordination of nickel(II).

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A Method for improving the Solute Selectivity of Osmotic Membranes

An examination of the results obtained with a pair of 'Ultracella' filters (fein)—manufactured by the Membranfiltergesellschaft, Göttingen—which had been used for several months in benzene at 30° C. to determine the number-average molecular weights ($\overline{M}_n$) of polymer samples, showed that during this time the membranes had become markedly less permeable to solvent. A similar observation has been made by Philipp and Bjork[1] with a gel 'Cellophane' membrane, and they attributed the phenomenon to gradual ageing of the membranes. However, with the 'Ultracella' filters (fein) closer examination of the results indicated that the change in permeability had occurred in two distinct stages both of which could be associated with attempts to measure the $\overline{M}_n$ of a sample of poly(diallyl phthalate). Experiments were therefore carried out with three other pairs of 'Ultracella' filters (fein) in order to investigate this phenomenon further.

The membranes were assembled in standard Zimm–Myerson type osmometers and before and after treatment with solutions of poly(diallyl phthalate) were characterized by (*a*) the solvent permeability, measured by the rate of fall of the meniscus in the measuring capillary under a head of 10 cm. of benzene, and (*b*) the solute selectivity, measured by the maximum osmotic head developed with a 1 per cent (w/w) benzene solution of a commercial polystyrene which has a very wide distribution of molecular weights[2].

The results in Table 1 show that in each case after treatment with poly(diallyl phthalate) the membranes became less permeable and more selective (that is, gave higher osmotic heads). Furthermore, these experiments show that the magnitudes of these effects (*a*) increased with poly(diallyl phthalate) concentration (membranes UCF/F 457/*A*1 and UCF/F 1256/4) up to a maximum concentration of about 1·5 per cent (w/v) (membranes UCF/F 1256/5), (*b*) after 16 hr. were independent of the time the membranes were in contact with the poly(diallyl phthalate) solution (membranes UCF/F 1256/4), (*c*) in the molecular weight-range 13,000–22,000 were

Table 1. Measurements in Benzene at 30° C.; 'Ultracella' Filters (Fein) (UCF/F)

Treatment				Permeability		Selectivity	
Poly(diallyl phthalate) solution			Time left in osmometer (hr.)	Fall from 10 cm. head of benzene		Equilibrium osmotic pressure with 1 per cent (w/w) commercial polystyrene	
Sample	$\overline{M}_n$	Concentration (per cent) (w/v)		5 min. (cm.)	30 min. (cm.)	Pressure (cm.)	Time (hr.)
UCF/F 457/*A*1							
—	—	—	—	1·31	5·85	3·35	< 16
10·1	13,000	0·1	16	0·74	3·86	4·93	6
10·1	13,000	1·5	16	0·31	1·77	6·01	6
UCF/F 1256/4							
—	—	—	—	1·25	5·04	4·43	4
BSI	22,000	0·1	16	0·92	4·03	4·65	4½
BSI	22,000	0·1	64	0·68	3·35	4·97	< 18
BSI	22,000	1·5	16	0·33	1·91	5·94	< 21½
UCF/F 1256/5							
—	—	—	—	1·58	6·27	3·93	3
BSI	22,000	1·5	64	0·46	2·56	5·83	< 22½
10·1	13,000	10	16	0·51	2·62	5·72	8

Table 2. Measurements in Benzene at 30° C.; 'Ultrafein' Filters (UFF)

Treatment				Permeability		Selectivity	
Poly(diallyl phthalate) solution			Time left in osmometer (hr.)	Fall from 10 cm. head of benzene		Equilibrium osmotic pressure with 1 per cent (w/w) commercial polystyrene	
Sample	$\overline{M}_n$	Concentration (per cent) (w/v)		5 min. (cm.)	30 min. (cm.)	Pressure (cm.)	Time (hr.)
'Ultrafein' filter (gross) (UFF/G 1157/1)							
—	—	—	—	2·96	—	5·83	2½
BSI	22,000	1·5	66	0·74	—	7·99	~20
'Ultrafein' filter (fein) (UFF/F 457/2)							
—	—	—	—	1·20	4·89	4·94	22
BSI	22,000	1·5	16	0·99	4·30	5·72	21
'Ultrafein' filter (allerfeinst) (UFF/AF 457/*A*3)							
2*H*	25,400	0·4	352	0·045	0·296	7·30	168
				0·050	0·305	8·31	166

independent of the sample of poly(diallyl phthalate) used (membranes UCF/F 457/*A*1 and UCF/F 1256/4). This effect was also found with other types of membrane, for example, with all grades of 'Ultrafein' filters (UFF), in particular with the most porous grade, namely, 'gross', *G* (see Table 2).

Meyerhoff[3] has reported a similar phenomenon with some 'Ultracella' filters (feinst) which had been allowed to become saturated with a 0·5 per cent toluene solution of an oligostyrene (that is, a polystyrene of very low molecular weight, $\overline{M}_n = 1{,}200$). He attributed the effect to irreversible adsorption of the oligostyrene by the membrane material, an explanation similar to that suggested by Ferry[4] to account for the action of capillary-active substances in ultrafiltration techniques. A similar hypothesis would explain the results recorded here. However, in this case the adsorption of the poly(diallyl phthalate) may not be completely irreversible for in some cases a gradual increase in permeability has been observed during subsequent experiments.

The 10·1 sample of poly(diallyl phthalate) was obtained from W. Simpson of Metropolitan-Vickers Electrical Co., Ltd., and the samples *BSI* and 2*H* were prepared by B. Selton of this Laboratory. I wish to thank Miss S. A. Monksfield and Miss H. M. Sankey for assistance with the experimental work. This work forms part of the research programme of the National Chemical Laboratory and is published by permission of the Director.

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Detection of Certain Brominated Long-Chain Fatty Acid Esters by Gas Liquid Chromatography

EVIDENCE has recently been presented which demonstrated the effects of alteration of the chemical composition of the stationary liquid upon the resolution of the methyl esters of long-chain saturated and unsaturated fatty acids by gas-liquid chromatography[1–4]. When the adipate, glutarate and succinate polyesters of diethylene glycol were used as liquid phases, the more polar unsaturated fatty acid esters were retained on the column to a greater degree than the saturated members of similar carbon chain-length. The number and position of the unsaturated linkages appeared to be the dominating factors in determining the affinity of the component vapour for the stationary liquid. The greater the degree of unsaturation beyond the 9,10 position in the fatty acid ester molecule, the slower was the movement of the substance down the column. This effect appeared to be modified somewhat by the occurrence of a double bond closer to the carboxyl group, that is, before the 9,10 position, which tended to hasten the emergence of the compound from the column. Although the polyesters were much more efficient as stationary liquids than the comparatively non-polar 'Apiezon' and silicone greases[5,6] for achieving separations of saturated and unsaturated fatty acid esters, when samples of fatty acid esters of unknown composition were analysed by gas-liquid chromatography, the possible presence of esters of branched-chain acids, odd-numbered acids, and unusual mono-, di- and poly-unsaturated acids still made difficult the positive identification of the individual components on the basis of comparative retention times and volumes.

Bromination of a mixture which has been previously analysed chromatographically and then re-running the brominated sample has been a common technique for determining the presence of compounds containing double bonds. Bromine adds to the double bonds to form a dibromide, tetrabromide, hexabromide, etc., depending upon the degree of unsaturation. In the early methods which employed columns containing 'Celite 545' coated with 'Apiezon' at 200° C. for the determination of fatty acids by gas-liquid chromatography, detection of brominated components was not noted[5]. Under these conditions, the disappearance of certain compounds following bromination and rechromatography was indicative of those substances in the original mixture that contained unsaturated linkages. The chain-length and number of double bonds were estimated according to the comparative retention times and volumes. The position of the double bonds was then determined by additional oxidative procedures[7].

A study was undertaken in this laboratory in an effort to detect by the gas-liquid chromatographic technique the presence of brominated fatty acid esters on columns containing highly polar polyesters as liquid phases. A mixture containing 34 per cent of methyl stearate and 66 per cent methyl oleate was resolved on a chromatographic column 8 ft. long containing 60–80 mesh 'Celite 545' coated with 10 per cent glutarate polyester of diethylene glycol at 205° C. An ionization chamber was used as a detection device. The rate of flow of argon was 60 ml. per min. The stearate and oleate bands had corrected retention volumes of 570 ml. and 645 ml. respectively. Aliquots of the same mixture were brominated by several procedures and then reapplied to the same column. A chromatogram of the brominated mixture revealed the presence of three peaks in addition to that of the unchanged stearate (Fig. 1). It was unlikely that any of the peaks represented unbrominated oleate since their retention times were longer than that of oleate. This was further verified by rebromination of the mixture which when re-chromatographed did not alter the appearance of the chromatogram.

The retention volumes and percentage composition of the three new components are presented in Table 1. By altering the operating parameters, the largest peak (No. 3) was found to contain another component from which it was partially resolved.

It should be noted that other mono-unsaturated acid esters yielded volatile brominated products which could be detected under the operating conditions already defined of the gas chromatographic technique. However, when methyl linoleate was brominated and the products analysed, distinct peaks were absent, although after 13 min. a shift in the

Table 1. RETENTION VOLUMES AND PERCENTAGE COMPOSITION OF THE BROMINATED MIXTURE

Component No.	Corrected retention volumes	Percentage
2*	570 ml.	34
3	675 ,,	39
4	1,050 ,,	12
5	1,260 ,,	15

* Methyl stearate, unchanged by bromination.

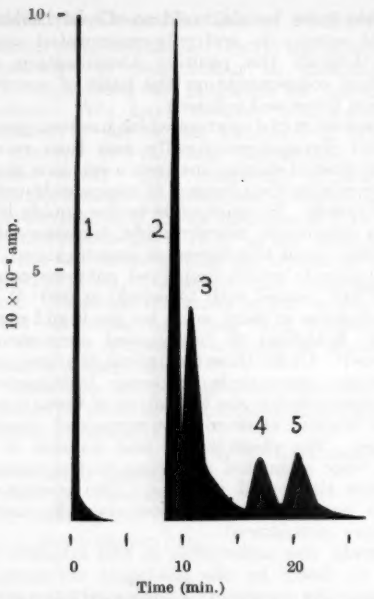

Fig. 1. Gas-liquid chromatographic analysis of a brominated mixture of methyl stearate (34 per cent) and methyl oleate (66 per cent), using an 8-ft. column containing 60–80 mesh 'Celite 545' coated with 10 per cent polydiethylene glycol glutarate at 205° C. Argon flow-rate, 60 ml./min. An ionization chamber was used as a detection device. 1, Solvent peak; 2, stearate; 3, 4 and 5, brominated products

base line was noted which continued for another 15 min. (The retention time of methyl linoleate under these conditions was 13 min.)

The exact chemical nature of the components found in the brominated mixtures is obscure. Although the materials appeared to be saturated when applied to the column, it is conceivable that dehydrobromination to yield mono-bromo-mono-unsaturated or doubly unsaturated compounds could occur during passage down the column. It is significant that even though side reactions may occur during or after bromination these nevertheless appear to be quantitatively reproducible. No differences were noted when (*a*) the bromination procedure was carried out by using pyridine sulphate dibromide in acetic acid or free bromine (1 per cent) in ether, and (*b*) the excess bromine was destroyed before removing the solvent or evaporated off along with the solvent.

The major brominated peak (Fig. 1, No. 3) is probably methyl 9,10-dibromostearate. The rapid emergence of this compound from columns containing polyesters as liquid phases is in sharp contrast to the behaviour of this substance when the 'Apiezon' greases were employed as stationary liquids. In these latter circumstances, detection of this material was noted only when the columns were operated[8] at 275° C. It cannot be determined at the present time whether or not the double peak (Fig. 1, No. 3) represents *d*- and *l*-dibromostearate, the anticipated product of bromination of a *cis* double bond.

When methyl elaidate was brominated, a similar pattern with much broader peaks was seen. Splitting of the major peak was not achieved, but this was no reason to believe it was homogeneous even though the *meso* dibromide is the expected product.

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Alleged Susceptibility of Sulphydryl Enzymes to Ionizing Radiation

Since the work of Barron *et al.*[1–3] it has been generally assumed that sulphydryl enzymes, in contrast to enzymes not requiring free SH-groups for their activity, are exceptionally susceptible to the indirect action of ionizing radiation. This view, which has profoundly influenced radiobiological thinking during the past decade, is not supported by recent experiments in this laboratory. In the present communication results are presented to show that the sulphydryl enzymes muscle glyceraldehyde-3-phosphate dehydrogenase and yeast alcohol dehydrogenase are inactivated by X-rays with about the same ionic yield as various non-sulphydryl enzymes.

Crystalline muscle glyceraldehyde-3-phosphate dehydrogenase (specific activity $3{\cdot}8 \times 10^5$ as defined by Velick[4]) and crystalline yeast alcohol dehydrogenase (specific activity $1{\cdot}8 \times 10^5$ units per mgm. protein[5]) were prepared[4,5]. In both cases the enzyme activity was determined spectrophotometrically under conditions of substrate and coenzyme concentrations which are optimal for measuring the activity of the apoenzyme[3,4].

It appears from Table 1 that when irradiated in dilute aqueous solutions equilibrated with air, both enzymes were inactivated by X-rays with ionic yields of about 0·02. These yields fall in the same range as those previously reported for a number of non-sulphydryl enzymes[1,2,6–8], providing evidence that glyceraldehyde-3-phosphate dehydrogenase and alcohol dehydrogenase are not particularly sensitive to the indirect action of ionizing radiation. The results stand in striking contrast to the reports by Barron *et al.*[1–3] that these enzymes are inactivated with ionic yields of about 1. Furthermore, the claim that glyceraldehyde-3-phosphate dehydrogenase can be partly reactivated by addition of reduced glutathione after irradiation[1] could not be confirmed.

The results here reported do not constitute evidence against the view that protein SH-groups are highly susceptible to ionizing radiation. Since the most active alcohol dehydrogenase preparations contain up to 36 titratable SH-groups[9], the present results with alcohol dehydrogenase are consistent with the assumption that in solution each accessible SH-group is inactivated with an ionic yield of about 1. A linear relationship is known to exist between the number of free SH-groups (in the interval 4·5–36) and the enzyme activity[9]. The present finding that aged alcohol dehydrogenase preparations with lower specific activities are inactivated with unchanged ionic yield (Table 1) suggests that the disappearance

Table 1. INACTIVATION OF GLYCERALDEHYDE-3-PHOSPHATE DEHYDROGENASE (GAPDH) AND ALCOHOL DEHYDROGENASE (ADH) BY X-RAYS

Irradiation conditions: 70 μgm. glyceraldehyde-3-phosphate dehydrogenase per ml. 0·07 *M* phosphate buffer, *p*H 7·4 (5×10^{-2} *M*); 45 μgm. alcohol dehydrogenase per ml. 0·01 *M* phosphate buffer, *p*H 7·4 (3×10^{-2} *M*). The enzyme solutions, equilibrated with air, were irradiated at 3° C. Irradiation factors: 4 m.amp., 200 keV., 0·5 mm. copper filter

Enzyme	Specific activity	Radiation dose (r.)	Remaining enzyme activity (per cent)	Ionic yield*
GAPDH	$3·8 \times 10^5$	0	100	—
		585	92	0·023
		1,170	84	0·023
		2,340	69	0·022
ADH	$1·8 \times 10^5$	0	100	—
		585	89	0·020
		1,170	76	0·020
		2,340	54	0·020
ADH	$7·6 \times 10^4$	0	100	—
		2,340	54	0·020
ADH	$4·56 \times 10^4$	0	100	—
		2,340	53	0·020

* 1 r. is assumed to give 3×10^{-8} *M* ion-pairs in solution

of free SH-groups accompanying the fall in activity[9] does not influence the ability to capture radicals of the sulphur atoms in question. Probably the ageing involves the conversion of SH- to SS-groups, which are likewise known to be highly susceptible to the indirect effect of ionizing radiation.

A complete report of this work will appear elsewhere.

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Phylogenetic Distribution of Acid Phosphatase inhibited by (+)-Tartrate

AN interesting stereo-specific inhibition by (+)-tartaric acid of certain acid phosphatases of human origin has been reported by Abul-Fadl and King[1]. We have had occasion in our work to note, as certainly many others must have, that inhibition by (+)-tartrate is a property which extends to other mammalian phosphatases. On the other hand, we have observed that none of a number of acid phosphatases present in crude extracts obtained from higher plants was preferentially inhibited by this substance. On further investigation of acid phosphatases of both plant and animal sources, we have consistently found the property of specific inhibition by (+)-tartrate to be associated with those organisms which are universally accepted as members of the animal kingdom, whereas those which are customarily regarded as plants invariably did not possess such an enzyme. In view of this sharp division, it became of interest to examine

Table 1. INHIBITION OF BIOLOGICAL ORGANISMS BY (+)-TARTRATE. The reaction mixtures consisted of 2 ml. of *p*-nitrophenyl phosphate (0·015 *M* in 0·1125 *M* acetate buffer, *p*H 5·0), 0·5 ml. of inhibitor, and 0·5–2·0 ml. of enzyme in a final volume of 4·5 ml. The tests were carried out with the aqueous extracts of the various organisms, essentially as described previously (ref. 2)

Source	Per cent inhibition by tartrate (+)-isomer 0·02 *M*	(−)-isomer 0·02 *M*
Monezia expansa	51	10
Ascaris lumbricoides	37	0
Snail (*Helisoma* sp.)	45	0
Crayfish (*Orconectes* sp.)	67	0
Cockroach (*Periplaneta americana* (L.))	48	0
Chicken liver	32	0
Rat liver	63	0
Human prostate	93	0
Physcomitrium turbinatum	0	0
Ginkgo biloba, seed	0	0
Brassica oleracea	0	0
Tetrahymena pyriformis	33	0
Euglena gracilis	58	0
Astasia longa	33	0
Chlamydomonas pseudococcum	0	0
Polytoma obtusum	19	11
Physarum polycephalum	73	21 (0·04 *M*)
Blastocladiella emersonii	35	19
Rhizopus nigricans	0	0
Mucor sp.	0	0
Phytophthora parasitica	62	18
Pythium ultimum	46	19
Neurospora crassa	51	0
Penicillium sclerotiorum	30	0
Aspergillus oryzae (taka-diastase)	36	0
Ceratostomella fimbriata	65	0
Stemphillium radicinum	39	0
Glomerella sp.	418	0
Agaricus campestris	62	0
Puccinia recondita (uredospores)	39	0
Saccharomyces cerevisae	0	0
Sporobolomyces sp.	0	0
Leuconostoc mesenteroides	0	0
Bacillus coagulans	0	0
Thermoactinomyces sp.	20	20
Streptomyces griseus	0	0
Actinomycetes sp.	0	0

the protists, and these results are shown in Table 1, along with those obtained with *bona fide* 'plants' and 'animals'. Only a few examples of the many which are available for the higher plants and animals are given. We have listed all the lower forms of plants and animals and of the protists which we have been able to test (except a number of bacteria, all of which were negative).

Several points of interest may be noted. In no case have we encountered an exception to the rule that 'unequivocal' plants lack, and animals possess, phosphatases inhibitable by (+)-tartrate. The euglenids are like the animals; the superficially similar chlamydomonads are like the plants. *Tetrahymena pyriformis*, a true protozoan, is, by this criterion, animal-like. All the bacteria tested, including the morphologically complex Actinomycetes, are plant-like. So also are *Saccharomyces cerevisae*, an ascomycetous yeast, and *Sporobolomyces*, which forms ballistospores. Among the Phycomycetes, it was found that *Rhizopus* and *Mucor* species do not possess the inhibitable phosphatases, whereas *Phytophthora*, *Pythium* and *Blastocladiella* do. The crude acid phosphatase of the slime mould, *Physarium polycephalum*, was very sensitive to (+)-tartrate. All the species of Ascomycetes and Basidiomycetes tested contained the inhibitable enzyme.

We do not wish to emphasize unduly the 'animalness' of the lower organisms; we realize that the dichotomy of the plant and animal kingdom may be no more than a man-made division. Neither do we wish to presume that there are only two main phylogenetic trunks. Nevertheless, we do direct attention to the possible utility of inhibition by (+)-tartrate as a taxonomic device, even if it may not necessarily

hold any profound implications for the moot problem (to some biologists) of how one tells the plants from the animals.

A word of caution needs be expressed. In all cases only crude extracts were tested. Not all animal phosphatases are inhibited by (+)-tartrate, and it should be noted that a concentration of 0·02 *M* (+)-tartrate, which is sufficient to cause a 93 per cent inhibition of the prostatic acid phosphatase, a source of acid phosphatase fairly homogeneous with respect to a single phophomonoesterase, did not cause a similar degree of inhibition with other animal phosphatases. With the animal preparations shown, it is possible that these do contain some non-inhibitable phosphatases as well. It is not impossible that extracts which we report as non-inhibitable do contain quantities of phosphatases inhibitable by (+)-tartrate too small to be significant in our assay. The possibility that the inhibition was due to non-specific ionic effects or to sequestering of essential cations was controlled by the use of (−)-tartaric acid.

We are greatly indebted to our many biologist colleagues at the University of California in Los Angeles, the University of Michigan, Michigan State University, and Purdue University for many of the organisms used in this work.

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Occurrence of α-Picoline in Plants

Wilkinson[1] has recently directed attention to the occurrence of α-picoline in the leaves of *Rumex obtusifolians*, which is believed to be the first record of the presence of this substance in plant material.

It is perhaps of interest to refer to some earlier investigations on the occurrence of a fluorescent alkaloid in rye-grass (*Lolium perenne* L.), in which was also recorded the isolation of other less-complex nitrogenous substances including a picoline-like compound[2,3]. This compound was not completely identified; but its absorption spectrum and empirical formula were indistinguishable from those of a picoline. However, close comparisons between the melting points and mixed melting points of the picrates and mercurichlorides with those of the α, β and γ picolines failed to identify the base, as did comparisons with the melting points of the fully hydrogenated derivatives. Moreover, no acidic products were obtained during oxidation under conditions which resulted in the formation from α-, β- and γ-picolines of the corresponding acids.

We have not had a further opportunity to investigate the nature of this base, but we are now prompted to recall our findings in the hope that these earlier results will be clarified by other workers.

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Fermentation of Glucose by *Chlorella vulgaris*

It has been shown recently that the chief products of glucose fermentation by *Chlorella vulgaris* (Pearsall's strain) are acetic acid, lactic acid, hydrogen and a little carbon dioxide[1]. It was of interest to study the fermentation of glucose labelled with carbon-14 in particular carbon atoms since, from a determination of the distribution of carbon-14 in the molecules of the products, something can be learnt of the fermentation pathway.

2 μc. and 1·5 μmoles glucose were supplied to 40 mgm. dry weight *Chlorella* suspended in 2 ml. 0·02 *M* phosphate, *p*H 7·0, in Warburg flasks which were filled with oxygen-free nitrogen; the flasks were shaken at 25° C. in darkness. The radioactive glucose was supplied by the Radiochemical Centre, Amersham, and was labelled in either the 1, 2 or 6 carbon atoms or was uniformly labelled. Carbon dioxide was collected in sodium hydroxide in the centre-wells of the Warburg flasks. When fermentation had ceased, the centre-well solutions were withdrawn and the carbonate precipitated and counted as barium carbonate after the addition of 1·5 mmoles sodium carbonate as carrier. The cell suspensions were removed, 1·5 mmoles acetic acid and 1·5 mmoles lactic acid added to each and the cells killed by heating to 100° C. The cells were extracted with hot water and the extracts run through columns of 'Zeokarb 215' to remove amino-acids. Acetic acid was then removed by steam distillation. Lactic acid in the residue was obtained either by ether extraction or by separation on a silica-gel column[2]. The acetic and lactic acids were then degraded[3] and their carbon atoms recovered as carbon dioxide. All counts were made on barium carbonate samples of infinite thickness. The distribution of carbon-14 is shown in Table 1.

Table 1. The Distribution of Carbon-14 in the Acetic Acid and Lactic Acid produced during the Fermentation of 1·5 μmoles and 2 μc. of Glucose-1-^{14}C, Glucose-2-^{14}C or Glucose-6-^{14}C by *Chlorella vulgaris*

The figures show the percentage of the total radioactivity contributed by each carbon atom in the molecules of the products. The last column shows the radioactivity in the carbon dioxide produced by the fermentation

Glucose supplied	Acetic acid CH_3—COOH		Lactic acid CH_3—CHOH—COOH			C.p.m. in carbon dioxide
Glucose-1-^{14}C	98·5	1·5	81·0	0·3	18·7	589
Glucose-2-^{14}C	1·7	98·3	0·7	85·9	13·4	363
Glucose-6-^{14}C	98·2	1·8	87·0	0·1	12·9	335
Uniformly labelled	—	—	—	—	—	1,071

The results show that the 1- and 6-carbon atoms of glucose are converted to the CH_3- carbon of lactic and acetic acids while the 2-carbon atom is converted to the —CHOH— carbon atom of lactic acid and to the —COOH carbon of acetic acid. This is the labelling pattern which would result if glucose were split by the Embden–Meyerhof–Parnas glycolysis reactions into two C_3 fragments which were either converted to lactic acid or decarboxylated to a precursor of acetic acid. In agreement with this view is the fact that most of the carbon dioxide produced during the fermentation appears to arise from the 3- and 4-carbons of glucose. The yield of carbon-14 dioxide from uniformly labelled glucose is much greater than that from the 1, 2 or 6 labelled sugar. If one assumes that the contribution of the 5-carbon of glucose to the carbon dioxide production is equal to that of the

2-carbon, the relative contributions of the glucose carbons to the carbon dioxide production can be calculated as (per cent): C_1, 9·2; C_2, 5·7; C_3 and C_4 together, 74·2; C_5, 5·7; C_6, 5·2. Nevertheless, all the glucose carbons contribute to the carbon dioxide production and the 1-carbon contributes more than the 6-carbon. Consequently, reactions other than the Embden–Meyerhof–Parnas glycolysis ones must be involved to some extent.

The labelling of the carboxyl group of lactic acid is noteworthy. It is probably a result of carbon dioxide fixation, which is known to occur during glucose fermentation by *Chlorella*[1].

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Isolation of Oxo-Steroids under Neutral Conditions

Girard's reagent *T* (trimethylammonium hydrazide chloride)[1] is extensively used for the separation of oxo-steroids from other steroids and particularly for purification of 17-oxo-steroids in extracts of acid- or enzyme-hydrolysed urine[2]. The method employed usually involves dissolving the material and Girard reagent in glacial acetic acid, and either heating the mixture for periods of up to 1 hr. or allowing it to stand overnight at room temperature. During this procedure destruction of labile steroids and some acetylation of hydroxy-steroids tend to occur (ref. 3 and unpublished observations).

Before extraction of non-ketonic material from the water-soluble Girard complex the acetic acid is nine-tenths neutralized by addition of strong alkali. The heat evolved, which may be deleterious to some steroids, is counteracted by carrying out the neutralization under ice-cold conditions. After extraction of the non-ketonic material the Girard complex is hydrolysed by taking the solution to *p*H 1 and allowing it to stand for 2–48 hr. Under these conditions destruction of labile steroids may occur.

Recently, Teitelbaum[4] has described an elegant modification of the method for application to labile aldehydes and ketones such as citral, benzaldehyde, etc., which are extensively destroyed by the old method. The new method involves forming the Girard complex in ethanolic solution in the presence of cation exchange resin ('Amberlite *IRC*50'), and then splitting the complex by adding excess aqueous formaldehyde. Thus many of the disadvantages of the old method have been avoided, and also the new method is simpler and less time-consuming.

The applicability of the new method to oxo-steroids has therefore been investigated. In these exploratory experiments the steroids used were progesterone (I) and 21-hydroxy-5β-pregnane-3 : 20-dione (II) (pregnanediolone). The steroid (10 mgm.) was dissolved in 1 ml. ethanol and 20 mgm. Girard reagent *T* and 5 mgm. 'Amberlite *IRC*50' were added. The mixture was heated under reflux for 1 hr., and after addition of 10 ml. water was extracted 3× with 10 ml. solvent (ether for I, ethyl acetate for II). The amount of steroid appearing in this non-ketonic fraction was then determined. After addition of 2 ml. of 40 per cent formalin, the aqueous solution of the Girard complex was allowed to stand overnight. Extraction with solvent then yielded the ketonic fraction. For comparison 10 mgm. steroid were also treated by the old method[3].

The results presented in Table 1 show that the new method is more effective than the old.

Table 1

Steroid	Percentage recovery from: (*a*) Non-ketonic fraction	(*b*) Ketonic fraction
Progesterone:		
Old method	0·5–1·5	82–86
New method	0·4–1·0	92–96
21-Hydroxy-5β-pregnane-3 : 20-dione:		
Old method	< 1	80–82*
New method	< 1	90–95

* Approximately 10 per cent of product was acetylated at C-21.

Further experiments were carried out with progesterone to determine the rate of formation of the Girard complex at room-temperature using the new method. The results are shown in Table 2. It can be seen that complex formation is fairly rapid at room temperature, and is virtually complete in 7 hr.

Table 2

Time (hr.)	0·25	0·5	1	2	3	7	24
Progesterone in non-ketonic fraction (per cent)	84	76	55	15	10	3	1

The rate of splitting of the Girard reagent–progesterone complex by formaldehyde was also investigated, and the results are shown in Table 3.

Table 3

Time (hr.)	0·1	1	7	17	24
Progesterone in ketonic fraction (per cent)	40	76	95	98	98

Thus it is apparent that this new method of using the Girard reagent is applicable to steroids, and in view of the mild conditions employed it is recommended for use, particularly in work with labile steroids.

I wish to acknowledge gifts of steroids from Drs. C. L. Hewett (Organon) and G. D. Laubach (Pfizer).

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Electroencephalograph Correlates of Ammonium Carbonate Intoxication in the Rat

In the literature[1,2] relating to ammonia intoxication in man and animals, the basic assumption has been that ammonia exerts a primary chemical action on brain cells. However, of the two papers in the animal experimental group on the effect of ammonia on the functioning of the central nervous system using electroencephalography, Marsan *et al.*[3] interpreted the transiently decreased electrical activity observed in the dog's brain as a direct consequence of general cellular anoxia due to an embarrassed cardiac output; and Torda[4] believed her results indicated an increase in cerebral activity because of the paroxysmal slow waves following the intraperitoneal injection of ammonium chloride. We have demonstrated that under proper conditions of administration of ammonium salt, a primary cortical neuronal response may be achieved, as evidenced by a decreased electric output.

11 per cent (w/v) of ammonium carbonate (reagent grade) in glass-distilled water was administered intravenously in divided doses of 27–220 mgm./kgm. of body-weight to segregated female Sprague–Dawley rats weighing 239–300 gm. A total of 63 experiments was performed. All electrode implantations, vessel and tracheal cannulations were performed under ether anæsthesia. Some animals were later immobilized by tubocurarine intravenously administered. In these cases, the curarizing material was injected slowly and titrated to the level of either minimal electroencephalographic change, or to the cessation of respirations, whichever appeared first. Oxygen was administered by an intermittent positive pressure system. The electroencephalograph derivations were obtained by means of small brass woodscrews placed in the homologous bilateral frontal and occipital regions of the skull. Variations in blood pressure were transduced with a Statham type 23 *A* strain-gauge, suitably connected to the abdominal aorta. The electrocardiograph was derived from clips attached to the skin behind the forepaws. All electrical measurements were made with Offner 141 amplifiers and dynagraph records. The ammonium carbonate was administered intravenously over an interval of 10–20 sec., in doses of 27–55 mgm./kgm. body-weight.

Section 4 of Fig. 1 is representative of the control electroencephalograph, electrocardiograph and blood pressure. In section 5 with the administration of ammonium carbonate in two successive doses of 55 mgm./kgm. each, a decrease in amplitude of the electroencephalograph was observed within 20 sec.; no substantial alteration in the heart function was recognized. Section 6 shows recovery of the brain activity to its control type. This section also shows the electrical activity at the end of the third administration of the chemical. Within 1 min. after this latter injection, section 7 again illustrates the decrease in amplitude of the output of the electroencephalograph. Array 8 shows the electroencephalograph activity 1 min. after the preceding; it is observed that the output becomes almost isoelectric; the heart function shows no evidence of impairment. Approximately 10 min. after the preceding section of waves (section 8), recovery again took place in section 9. Section 10 shows tracings, 1½ min. after the injection of only 55 mgm. of ammonium carbonate per kgm. body-weight. The isoelectric output is evident. We have accomplished such recycling repeatedly. Clinically the animals remain in a state of unresponsiveness during the interval of diminished electrical output; they can in no way be considered 'alerted'.

Ulshafer[3] showed that rats injected with ammonium carbonate had a consistent diminution in the acetylcholine-level of the brain as compared with controls. Larger doses of the chemical decreased the measured amount of acetylcholine of the brain. He suggested that the decreased brain acetylcholine resulted from the action of the ammonium ion in the conversion of glutamic acid to glutamine. We believe, therefore, that the electroencephalographic changes demonstrated are consistent with, and an expression of, a reduced acetylcholine content of the brain.

In conclusion, our material demonstrates that ammonium carbonate has a direct action on the central nervous tissue of the rat. This action is to reduce spontaneous electrical output.

The technical assistance of Donald H. Lentz and Dr. Morris H. Lampert is acknowledged.

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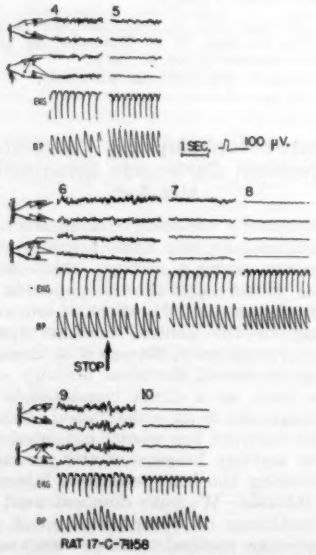

Fig. 1

Dependence of Latent Period in Muscle on Strength of Stimulus

The so-called latent period, which includes latency relaxation, has an important bearing on theories of excitation coupling. It is surprising then that systematic studies[1,2] of this phenomenon do not mention the role of the stimulus. The reason is that, with the frog sartorius, increasing strength of stimulus above twice the threshold value apparently produces no significant effect on the latency, while below this value the effects may conceivably be dismissed as due to 'recruitment of fibres'. Even here, however, latency relaxation increases and may reach as much as 1 per cent of tetanus tension at ten times threshold field-strength.

In my experiments, to eliminate conduction-time effects, stimulation is by transverse field—an arrangement introduced by Brown and Sichel[3] in their study of single sartorius fibres. It is noteworthy that the records of these authors (their Fig. 6, p. 324) show clear evidence of decrease of latent period with increase of field, as well as increase of twitch tension.

These effects can be seen in whole muscles other than the sartorius in much more striking form. Fig. 1 shows a result obtained with a muscle similar to toad sartorius. With increasing field three effects occur in

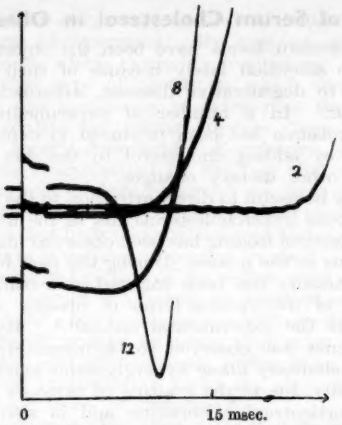

Fig. 1. Latent period in r. capitis collique of turtle (*Chrysemys pictans*) at 0° C. Ordinate: tension. Figures refer to stimulus strength in V./cm. Duration of stimulus, 1·5 msec. (shown superimposed on tension record)

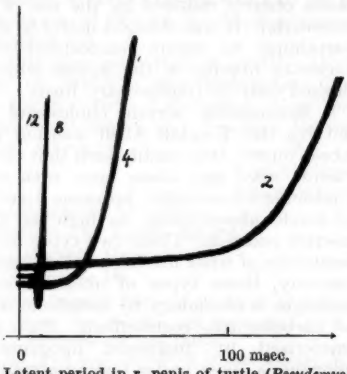

Fig. 2. Latent period in r. penis of turtle (*Pseudemys elegans*), 0° C. Duration of stimulus, 3 m.sec. Note that latency relaxation begins at 8 V./cm. while the record for 12 V./cm. is virtually superimposed on this

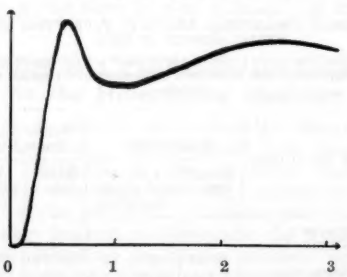

Fig. 3. Subsequent isometric development of tension for curve of Fig. 2 for 8 V./cm. Second peak corresponds to normal twitch as obtained from a propagated action potential

sequence: (1) decrease of latent period; (2) increase of initial rate of development of tension; (3) onset of latency relaxation.

The same is true for a slow tonic muscle (Fig. 2) where, however, effects 1 and 2 are much greater and occur simultaneously. In fact the effect 2 is so great as to show a spike of tension (Fig. 3), reminiscent of a 'quick stretch' effect[4], superimposed on the normal twitch response. By varying the duration of the stimulus one finds that the time constant for the process involved is about 1 msec.

These observations are consistent with the view that by transverse stimulation we can drive the membrane to greater amplitudes than the normal propagated action potential, thereby accelerating a process precursor to activation.

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Lysins and Agglutinins in Normal and Lymphomatous Mouse Tissue

Lysins and agglutinins have been extracted from normal mouse tissues, and often in much higher concentration from the mammary adenocarcinomas of the female *C3H* mouse. Three methods have been used for extraction[1–4]: (*a*) extraction of minced-up tissues in saline (1 per cent sodium chloride), (*b*) 'pre-incubation' of homogenized tissue at 37° C. in saline for 12–18 hr., which results in the separation of a yellow hæmolytic fluid, and (*c*) extraction with ether, which gives an ether-soluble 'soap-like' lytic material and also a lytic material insoluble in cold ether ('lysolecithin'). These methods and their results have been reviewed by Ponder[3] in relation to a background which begins with the work of Metchnikoff in 1893. Probably only method (*a*) is of real value for demonstrating tissue lysins and inhibitors; the other two methods are to some extent unreliable since they involve the splitting of pre-existing complexes.

Recently, Pirofsky[5] has obtained lysins and agglutinins, detected by trypsinized red cells, from the white cells of human leukæmia (7 chronic lymphatic, 4 chronic myelogenous and 2 acute leukæmias). Many, but not all, of the properties of these extracted substances are like those of extracts of mouse tissues and tumours, but the extraction media used are different (30 per cent sucrose, 11·5 per cent sodium chloride and 0·82 per cent sodium chloride), and neither the lysin nor the agglutinin was found to be soluble in alcohol or ether. They are not related to the β-hyaluronidase described by Leroy and Spurrier[6], and a non-dialysable substance in plasma inhibits their action.

This communication is concerned with the lytic and agglutinating properties of fresh homogenized lymph glands from normal and leukæmic (better termed lymphomatous) *AKR* mice. The mice are killed and the lymph nodes dissected out immediately; in the lymphomatous mouse, the thymus may be large and infiltrated with lymphoma cells. In the normal mouse, the tissue which is homogenized is the lung. Blood is withdrawn from the heart. The nodes (normal and lymphomatous as determined later by section) are homogenized for 5 min. in a 'Vir-Tis' homogenizer moving at 35,000 rev./min., the proportion used being 200 mgm. of tissue in 1 ml. of saline. Centrifuging for a few minutes removes gross particles, and the homogenate is diluted with Michaelis's buffer at *p*H 7 in powers of 2. The red cells obtained from the heart are washed three times with saline, packed, and 0·1 ml. suspended in 10 ml. of saline. They are not trypsinized. A volume of

Table 1

Tissue	1 hr.	2 hr.	3 hr.
Normal	3, 4	2, 3, 4	2, 3, 4
Normal	0	0	0
Normal	0	0	2
Leukæmic	0	3	3, 4
Leukæmic	2, 3	2, 3, 4	2, 3, 4, 5
Leukæmic	2, 3, 4	2, 3, 4, 5	2, 3, 4, 5

0·1 ml. of the dilute red-cell suspension is added to each tube containing 0·2 ml. of diluted homogenate. The tubes are placed in a water-bath at 37° C., and are observed for lysis or agglutination for 3 hr. Controls are included.

Table 1 is self-explanatory. Lysis (complete) and agglutination are expressed in terms of the tubes in which they occur; for example, lysis 3–4 means that complete lysis occurs in tubes 3 and 4 of the series of dilution of the homogenate in powers of 2. Tubes containing higher concentrations of the homogenate, for example, tubes 1 and 2, always show agglutination, whereas tubes containing smaller concentrations of the homogenate than those which produce lysis, for example, tubes 5, 6, etc., show neither lysis nor agglutination. So far as lysis is concerned, each series of dilutions shows a zone phenomenon like that described for extracts of mouse carcinoma[4]. The lytic phenomenon is dependent on *p*H, occurring in the highest dilutions of the homogenates at a *p*H between 7 and 8.

Lytic material can be extracted by adding to 1 volume of the homogenate either 3 volumes of hot alcohol or the same amount of hot ether or of cold (2° C.) ether, shaking, filtering, evaporating the alcohol or ether to dryness under a fan at room temperature, and taking up the dry residues with Michaelis's buffer at *p*H 7. This rapid method of extraction is preferable to the longer method described by Ponder[3], particularly when only small amounts of homogenate are available. If Pirofsky is right in saying that these methods fail to extract lytic material from human leukæmic cells, there is a demonstrable difference between the lytic substances of mouse tumours, mouse leukæmia and human leukæmia. Unfortunately, the extraction methods were devised to be applied to blood and to pre-incubated tissues, including mouse tumours; the lytic material is bound to proteins, from which it may be split off by the extraction. There is no reason for thinking that this lytic material is the same as that in homogenates which have not been pre-incubated and extracted, which sometimes produce lysis in less than an hour. The concentration and nature of the latter material are still unknown, except that it too seems to be associated with inhibitors (agglutinins), and that it is found in normal as well as malignant and leukæmic tissues of the mouse, the concentration in normal tissues, however, usually being small.

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Levels of Serum Cholesterol in Obese Mice

Cholesterol-levels have been the object of considerable attention lately because of their possible relation to degenerative diseases, atherosclerosis in particular. In a number of experiments hypercholesterolæmia has been produced in experimental animals by adding cholesterol to the diet and by making other dietary changes.

It may be useful to direct attention to the fact that spontaneous hypercholesterolæmia in the absence of any cholesterol feeding has been observed under three conditions in the mouse. During the past few years, this laboratory has been engaged in a study of the etiology of the various forms of obesity using the mouse as the experimental animal[1,2]. Hypercholesterolæmia was observed to be invariably present in the hereditary obese hyperglycæmic syndrome, in the obesity due to the grafting of tumours secreting adrenocorticotrophic hormone and is also seen in female yellow obese mice. By contrast, hypercholesterolæmia is not seen in goldthioglucose-hypothalamic obesity (nor, for that matter, in the hypothalamic obesity induced by the use of stereotaxic instruments). It was thought useful to compare results pertaining to serum cholesterol-levels in various forms of obesity in the mouse which have been published only in fragmentary form.

Table 1 summarizes serum cholesterol values determined by the Kendall–Abell method in four types of obese mice[3]. It is readily seen that the obese-hyperglycæmic mice and obese mice with tumours secreting adrenocorticotrophic hormone have serum cholesterol-levels about twice as high as those of their respective controls. These two types of obesity are representative of what has been called 'metabolic' obesity, namely, those types of obesities in which the hyperphagia is secondary to metabolic disorders of fat and carbohydrate metabolism. Such animals are characterized by increased lipogenesis and cholesterologenesis, even under fasting conditions[4,5]; by the retention of a high body-fat content even when the animals are reduced to the control weight

Table 1. Serum Cholesterol Levels in Four Types of Experimental Obesity in Mice

Results for the first three types of obese mice are for males and females pooled as there is no sex difference with respect to serum cholesterol levels

Types and No. of mice	Body-weight		Serum cholesterol (mgm./100 ml.)	
	Range (gm.)	Average and stand. deviation	Range (gm.)	Average and stand. deviation
Goldthioglucose:				
Hypothalamic obese (25)	42–63	53 ± 12	101–149	125 ± 24
Normal Swiss controls (25)	24–32	29 ± 3	71–153	112 ± 41
Obese hyperglycæmic				
Obese (20)	49–62	55 ± 18	134–220	192 ± 24
Normal *V*-stock controls (30)	21–33	27 ± 6*	74–116	106 ± 10*
Adrenocorticotrophic hormone†				
Obese (13)	22–32	28 ± 4	121–133	127 ± 6
Normal LAF_1 controls (14)	24–30	27 ± 3	66–74	70 ± 4*
Yellow mice:				
Obese (17)	46–56	51 ± 5	116–212	164 ± 48
Normal controls (black) (14)	32–42	37 ± 5*	153–227	190 ± 37
Females:				
Obese (17)	48–60	54 ± 6*	153–227	190 ± 37
Normal controls (14)	32–36	34 ± 2*	114–168	141 ± 27*

* Difference significant at 1 per cent level.
† Mice of LAF_1 strain grafted with pituitary adrenocorticotropin-secreting tumours.

and by other enzymatic, endocrine, metabolic and behavioural idiosyncrasies. By contrast, goldthioglucose mice, which exemplify 'regulatory' obesity, namely, that type of obesity in which the hyperphagia is due exclusively to a lesion in the higher nervous centres controlling appetite, have normal levels of serum cholesterol. Regulatory forms of obesity are characterized by the fact that rates of lipogenesis and cholesterologenesis are brought back to normal levels when hyperphagia is eliminated and by the fact that body composition goes back to normal when weight is reduced to control levels.

The cholesterol picture of the yellow mice parallels the more complex sex-linked situation observed in these animals[6]: the female mice, which are characterized by much greater adiposity and rates of lipogenesis and cholesterologenesis higher than normal when fasted (unpublished work) are also characterized by high levels of cholesterol.

It thus appears that obese mice of different types suitably compared may offer particularly good material for the study of factors influencing the concentration of serum cholesterol and for the study of the influence of this on the development of lesions of atherosclerosis.

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Toxicity of a Cholinesterase Inhibitor to the Hibernating Hamster

METABOLIC activity is profoundly altered in the hibernating animal, as compared with that in the normal. Evidence is also available that under hibernating conditions nervous function in certain species can be affected[1]. Consequently it was of considerable interest to determine the toxicity of a ganglionic blocking agent to animals under the abnormal metabolic conditions produced by hibernation. The toxicity of the cholinesterase inhibitor O,O-diethyl-S-2-diethylaminoethyl phosphonothiolate[2] has been determined in the nornal and hibernating hamster by the intraperitoneal route.

Hibernation was induced by keeping the animals in the cold. A group of one hundred male animals weighing between 100 and 130 gm., were kept in individual cages in the cold room. The temperature was adjusted to + 10° C. for the first week, then lowered to + 5° C. for the remainder of the experimental period. Animals were allowed 8 hr. of artificial light a day and disturbed as little as possible. Hibernation was induced in some animals as early as the sixth week and in others as late as the fifteenth week, by which time a total of forty animals had gone into hibernation. Inspection was carried out twice a day and toxicity determinations made 24 hr. after hibernation was first observed.

Handling of the animal, necessary for (intraperitoneal) injection, even if done with the greatest of care, initiates the waking mechanism, so that within a few hours the animal is active and apparently back to normal. Thus, strictly speaking, the results on toxicity refer to animals in the intermediate state between undisturbed hibernation and normal activity. Nevertheless, the rapid action of the inhibitor ensures that toxic symptoms are well established before a return to normal activity has been accomplished.

For each toxicity determination the inhibitor was made up afresh in anhydrous propylene glycol at a concentration of 1 mm.^{3}/ml., and an 'Agla' microsyringe was used for injection.

The *LD*50 determined on a normal group of 140 hamsters and calculated at the 5 per cent confidence limits by probit analysis was $0{\cdot}106 + 0{\cdot}006$ mm.^{3}/kgm. (intraperitoneal). The corresponding *LD*50 for the hibernating group was $0{\cdot}072 \pm 0{\cdot}012$ mm.^{3}/kgm. intraperitoneal.

The increased susceptibility of the hibernating group to the anticholinesterase is possibly a reflexion of the increased stress placed upon the animal by the cold environment or the metabolic readjustment necessitated by coming out of hibernation.

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Rate of Absorption of Supplementary Free Amino-Acids during Digestion

ANIMAL feeding studies have demonstrated that utilization of dietary protein is improved when an amino-acid deficiency is corrected by supplementation with free amino-acid. This greater utilization of protein is detected by the greater gain in body-weight of the test animal per unit of protein eaten, or by an increase in the percentage of ingested nitrogen retained by the animal. The improvement of the nutritive value of bread[1], rice[2] and maize[3] by supplementation with amino-acid has been demonstrated.

Although these investigations clearly point to nutritional improvement, supplementation of food proteins has been criticized on the grounds that the free amino-acids may be absorbed into the bloodstream before the amino-acids liberated by digestion of the protein. If this were so, the full value of the supplement would not be realized, since it has been demonstrated that efficient synthesis of tissue proteins occurs only when all the essential amino-acids are supplied simultaneously in the proper proportions[4].

The experiments reported here were designed to compare the rate of absorption of a free amino-acid supplement with that of the amino-acids liberated by digestion of protein. Healthy mongrel dogs were fasted for an 18-hr. period before being fed a meal

containing the test protein. Approximately 25 ml. of blood was obtained by cardiac puncture of the unanæsthetized dog immediately before the meal (zero time) and 1, 2, 3, 4 and 5 hr. after the meal. (The feeding tests and the blood sampling were carried out at the Food and Drug Research Laboratories, Inc., under the direction of Dr. M. Brin.) The plasma was analysed for the essential amino-acids by ion-exchange chromatography[5], except for tryptophan, which was determined by microbiological assay employing *Lactobacillus plantarum*.

The concentrations in the plasma of several essential amino-acids after the ingestion of a wheat gluten diet for dog No. 364 (with and without a lysine supplement) are compared in Fig. 1. After the unsupplemented wheat gluten meal, the first limiting amino-acid, lysine, shows a marked decrease. Typical non-limiting amino-acids, such as threonine and tryptophan, show a gradual increase and then a decrease during the five hours after the meal. The decrease in concentration of lysine indicates that some of the lysine reserve of the plasma is used up to allow partial utilization of the other essential amino-acids from the wheat gluten. This finding may explain why the determinations of biological value for low-quality proteins sometimes give higher values than would be expected from their amino-acid composition[6]. Apparently, the plasma can serve as an amino-acid reservoir and supply a limited amount of an amino-acid which is deficient in the protein ingested. Further amounts of limiting amino-acids may also be mobilized by depletion of the stores of labile protein. Therefore, in short-term studies a greater utilization of the dietary protein for tissue synthesis will be obtained than would be possible if the only amino-acid source were the food protein itself.

When wheat gluten supplemented with lysine is fed (2 gm. L-lysine monohydrochloride per 100 gm. protein, which is the optimum supplementation-level for bread determined by animal-feeding studies; ref. 1), the concentration pattern of the plasma lysine after the meal is similar to the pattern exhibited by the non-limiting essential amino-acids (see Fig. 1). Only threonine and tryptophan are shown in Fig. 1, but all the non-limiting essential amino-acids gave similar patterns. These results indicate a similar rate of absorption for the 'free' lysine and the amino-acids from the wheat gluten. This is evident because the increase in the concentration of plasma lysine would not extend over the first two hours after the meal nor would the lysine concentration be maintained as well after five hours if the 'free' lysine were absorbed at a markedly faster rate than the amino-acids from the protein.

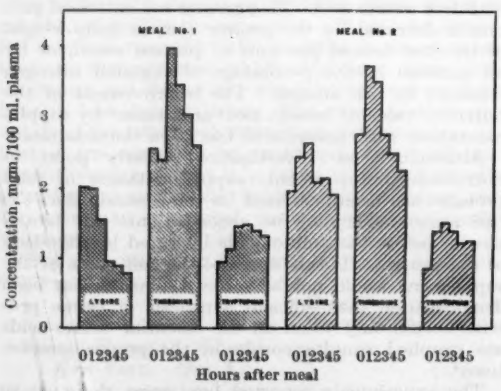

Fig. 1. Changes in blood plasma amino-acid after the ingestion of wheat gluten with and without L-lysine. Meal No. 1 contained 84·9 gm. wheat gluten (13·23 per cent nitrogen), 95·1 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water. Meal No. 2 contained 84·9 gm. wheat gluten, 1·3 gm. L-lysine-monohydrochloride, 93·8 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water

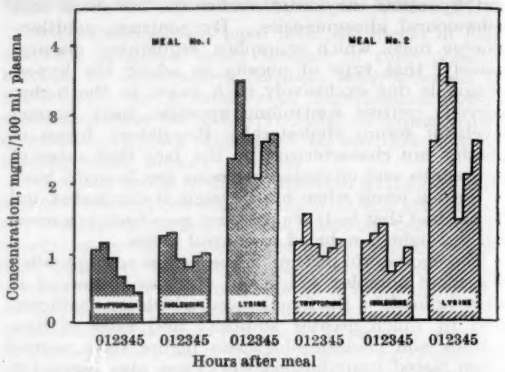

Fig. 2. Changes in blood plasma amino-acid after the ingestion of gelatin with and without L-tryptophan. Meal No. 1 contained 70·5 gm. gelatin (14·52 per cent nitrogen), 109·5 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water. Meal No. 2 contained 70·5 gm. gelatin, 0·3 gm. L-tryptophan, 109·2 gm. sucrose, 20 gm. cottonseed oil and approximately 150 gm. water

When this deficiency is corrected by addition of free tryptophan to the gelatin (0·5 gm. L-tryptophan per 100 gm. protein), the plasma tryptophan pattern after the meal is similar to the patterns of the other non-limiting essential amino-acids. This indicates that the free tryptophan is absorbed into the blood at a rate similar to that of the amino-acids from the gelatin.

An identical experiment was carried out on gelatin with and without supplementation with tryptophan using dog No. 365. The results are presented in Fig. 2. The tryptophan deficiency is revealed by a decided lowering of the concentration of plasma tryptophan after a gelatin meal.

Thus direct studies *in vivo* indicate that the addition of a free amino-acid to a protein is a practical method of overcoming an amino-acid deficiency of the protein. Since the amino-acid deficiency in the blood is corrected at the time when the other essential amino-acids are present at their maximum concentrations, optimum utilization of the essential amino-acids from the protein should be realized.

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Significance of Urinary Vanillic Acid

As a result of the observation that vanillic acid was excreted in abnormal quantities by some subjects exposed to stress, Smith and Bennett[1] suggested that the substance might be a metabolite of adrenaline or noradrenaline. In a recent communication[2] Shaw and Trevarthen considered these conclusions to be unjustified, since natural dietary precursors of the acid exist; in particular these authors found increased excretion of vanillic acid by one subject following ingestion of coffee. We therefore wish to emphasize that we were well aware of these facts long before we even observed high values in stress and carefully considered them before allowing our conclusions to appear in print; in point of fact I postulated that vanillic acid might be an adrenaline metabolite so long ago as 1954, but was for some time unable to obtain sufficiently unambiguous confirmatory evidence, since the technical imperfections of chromatographic methods coupled with the variations in excretion-rate observed in normal subjects were sufficient to mask any changes that may have occurred using other conditions of stress. A further experiment, which did not in fact confirm a high excretion of vanillic acid in driving-stress, has been the subject of a recent communication[3].

However, other observations, mostly of a rather scattered nature, have served only to convince us that the substance may arise endogenously, and an origin from adrenaline or noradrenaline is the only explanation we are able to offer. It must be admitted, though, that direct and conclusive evidence has not been easy to obtain. Thus in an experiment in which adrenaline was infused intravenously into a subject, vanillic acid was conspicuous in being one of the very few urinary phenols which was *not* excreted at an enormously increased rate, possibly as the result of diuresis. Since in any event the metabolism of, say, intravenously infused adrenaline may by no means be identical with the metabolism of adrenaline released from the adrenals, we have preferred to base our conclusions on inferences deduced from studies of excretion despite the pitfalls that may arise because of the practical impossibility of controlling diet.

It is indeed true that much—probably most—of the vanillic acid in normal urine is of exogenous origin. This is only to be expected since the normal rates of secretion of the sympathomimetic amines cannot be very high. However, in our British subjects most of whom rarely drink coffee, the rate of excretion of vanillic acid is rather low. On the few occasions when quantities approaching those observed in stress have been noted in normal subjects, other metabolites of caffeic and chlorogenic acids have been equally evident; these acids are probably quantitatively by far the most important exogenous source of vanillic acid. Studies on the metabolism of caffeic and its related acids have been carried out intermittently in these laboratories over a period of some five years; even so, we have not as yet been able to reach definite conclusions. Differences between the observations of Shaw and Trevarthen[2] and of Booth *et al.*[4], and between both these groups and ourselves concerning the metabolites detected after administration of coffee, for example, seem to be too significant to be readily explained away by possible variations in the source of the coffee. Some degree of clarification has been achieved since we now believe that methylation of 3 : 4-dihydroxyphenyl groups on the 4- as well as on the 3-position occurs far more generally than has been previously indicated[1,4], and some previously published observations may require modification. For example, if our experience is any guide, the increased excretion of vanillic acid after coffee noted by Shaw and Trevarthen[2] may be perhaps somewhat exaggerated since using the chromatographic technique employed by these authors we would expect to observe not vanillic acid alone, but a composite spot consisting of vanillic, *iso*vanillic and *iso*ferulic acids, in varying proportions according to the subject.

The dietary origin of much of the aromatic material in urine has been confirmed in these laboratories. Four urine samples were collected during the morning from each of seven subjects who had had no breakfast. As anticipated, the rates of excretion of many substances progressively diminished during the course of the experiments. In two subjects, however, well-defined increases in vanillic acid were observed in the acid-hydrolysed urines. In each case corresponding chromatograms of the unhydrolysed urines showed a parallel increase in 4-hydroxy-3-methoxymandelic acid. Since the latter compound is known to be a metabolite of noradrenaline[5,6], the experiments therefore indicate not only that vanillic acid may be formed endogenously but also support the suggestion of Smith and Bennett[1] that it is a metabolite of adrenaline or noradrenaline.

While there can be no doubt that the high values reported for vanillic acid were well beyond the normal range, the interpretation that the acid is a metabolite of adrenaline or noradrenaline is much less certain. In the first place, equally well-defined changes in the excretion of 3-ethoxy-4-hydroxybenzoic acid have now been reported in stress[3]. In view of the close chemical relationship of this substance to vanillic acid it would surely be too much of a coincidence if the increased excretion of both compounds had not a common basis. Until the possibility of biological ethylation has been clearly demonstrated the suspicion must therefore arise that both acids might have arisen because of the ingestion of sweets or other foodstuffs flavoured in some cases with vanillin, in others with ethyl vanillin. However, every care was taken to check that this was not so; in the case of the two subjects discussed previously[3] the possibility can certainly be excluded. In the second place, the formation of vanillic acid from the phenylethanolamines requires a plausible, if hypothetical, metabolic pathway. Consideration of the likely properties of possible intermediates has led us to favour a scheme represented in its simplest form by:

$$R.\mathrm{CHOH.CH_2NH}R_1 \rightarrow R.\mathrm{CHOH.CH{=}N}R_1 \rightleftharpoons R.\mathrm{CO.CH_2NH}R_1$$
$$\downarrow \qquad\qquad\qquad\qquad \downarrow$$
$$R.\mathrm{CHOH.COOH} \qquad\qquad R.\mathrm{COOH}$$

It is therefore of interest that in a preliminary experiment, oral administration of adrenalone (3 : 4-$(OH)_2$, $C_6H_3.CO.CH_2NHCH_3$) to a human subject has been found to result in the excretion of grossly abnormal quantities of vanillic, *iso*vanillic and 4-hydroxy-3-methoxymandelic acids. In the guinea pig, injection of either adrenaline or adrenalone has been reported to yield the same metabolite, believed to be protocatechuic aldehyde[7].

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Local Reaction to Non-metastasizing and Metastasizing Transplantable Tumours

The mechanism by which tumours spread into the surrounding tissues or produce metastases in distant organs is still an obscure problem. The reaction of the tissues of the host in relation to the rate of growth and metastasization has not been sufficiently investigated.

Bottiglioni and Prodi[1] observed that only the stroma of metastasizing tumours is rich in a metachromatic substance.

The present investigation aimed at studying the local reaction to non-metastasizing and metastasizing transplantable tumours, namely, the Walker adenocarcinoma and a rat sarcoma (non-metastasizing tumours at expansive growth), rat tumour Guérin *T*58 (non-metastasizing, in our strain, at infiltrative growth), rat tumour Guérin *T*8 (metastasizing, lymphotrope) and the rabbit Brown Pearce tumour (which produces metastases in lymph nodes and parenchymatous organs).

The tumours were transplanted with the usual technique, those of the rat subcutaneously, and the Brown Pearce tumour in the testis. The animals were killed when tumours had attained maximal development. Both primary tumours and metastases, when present, were removed with their surrounding tissue and studied with appropriative connective tissue stainings.

Investigations were carried out on material from sixty-five animals.

Around the grafts of Walker adenocarcinoma and rat sarcoma no connective tissue reaction was macroscopically detected; microscopically, the boundaries between tumour cells and host tissue are well outlined. The host tissue shows a considerable number of mast-cells, forming a sort of barrier around the tumour mass. Some of these cells are degranulated, some packed with granules. The fibroblastic reaction is rare.

Tumour *T*58 seems to become identified with the adjacent tissues. Its cells penetrate into the dermis and muscle, directly replacing the tissues without any kind of reaction.

Around tumour *T*8, in both the primary site and particularly around the metastases in superficial lymph nodes, a layer of loose connective tissue, sometimes of a mucous type, is observed; this tissue is rich in fibroblasts, and the loose fibrillar texture assumes a clear-cut metachromatic colour when stained with toluidine blue. Here and there the tissue takes the aspect of a thin extracellular network which shows intense metachromasia. If sections are pretreated with hyaluronidase, metachromasia does not occur. The mast-cells are scanty. Many round-shaped structures, which apparently are hectasic lymphatic vessels, are observed. The connective tissue is infiltrated with tumour cells which occasionally are also seen inside the lumen of these vessel-like structures.

Both around the primary tumour and the metastases (in the liver, kidney, lung, lymph nodes and peritoneal membranes) of Brown Pearce tumour an intense connective tissue reaction is observed with a large amount of highly metachromatic substance, which is destroyed by pretreatment with hyaluronidase. The tissue is of a loose fibrillar type, with often numerous fibroblasts and infiltrated with tumour cells.

The presence of a mast-cell barrier around the grafts of Walker adenocarcinoma and rat sarcoma which do not metastasize and grow extensively may indicate a defence against infiltration: such a hypothesis has already been suggested by Sylvén in relation to skin carcinogenesis[2]. This observation seems to be confirmed by the fact that there is little or no such reaction around tumour *T*58, which is infiltrative.

As regards metastasizing tumours, the tissue reaction is represented by a loose connective tissue which does not change into thickly fibrous tissue. This, with some differences, is a common character of the Brown Pearce and the *T*8 tumours. The reaction of connective tissue interposed between host and tumour tissue forms a sort of third section which is easily invaded by tumour cells and which, being rich in vascular formations (which are particularly evident around *T*8 tumour), facilitates their passage into the circulation and consequently the onset of metastases.

These considerations suggest that the rate of growth as well as the ability to induce metastases may not be directly dependent upon intrinsic characters of the cell but rather upon the reaction induced and established by the tumour cell in the host tissue.

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Changes in the Potassium Concentration and Metabolism of Red Blood Cells of the Lamb

Many investigations have been made attempting to relate the potassium content and transport in red blood cells to the glycolytic activity of the cells[1,2]. Such investigations have utilized red blood cell suspensions which have been stored at low temperatures in order to obtain partial depletion of the cells with respect to potassium.

Widdas[3] has shown that the potassium content of fœtal sheep red blood cells is considerably higher than that found in the mature animals of the same breed. At birth the potassium concentration in the cells is high and decreases with increasing age of lamb. Thus successive samples of red blood cells from the same lambs can produce systems in which marked differences in the concentration gradient $(K^+)_i/(K^+)_o$ exist.

In preliminary experiments, we have made measurements of the potassium and sodium content, oxygen uptake and glycolytic activity of red cells obtained from lambs over the period 12–60 days of age.

Venous blood samples were taken into heparin, centrifuged, the red blood cells isolated, washed with

Table 1

Lamb No.	Age (days)	[Na+] m.equiv./l. Initial	[Na+] m.equiv./l. Final	[K+] m.equiv./l. Initial	[K+] m.equiv./l. Final	Qo_2 µl./ mgm. dry wt./ hr.	Qlactic acid µgm./ mgm. dry wt./ hr.
1	14	41	38	95	95	0·033	—
	31	120	104	23	25	0·024	0·34
	44	117	116	11	11	0·014	0·49
	63	125	119	3	3	0·013	0·17
2	12	56	60	82	77	0·021	—
	29	99	92	32	34	0·011	0·35
	42	103	100	24	24	0·012	0·45
	61	108	103	7	7	0·011	0·26
3	13	67	54	76	81	0·020	0·47
	26	92	94	37	39	0·015	0·53
	45	112	110	6	6	0·012	0·24
4	13	77	67	74	78	0·019	0·37
	26	107	97	40	39	0·017	0·45
	45	115	111	5	5	0·012	0·25

phosphate buffer solution (1·5 ml. *M*/2 potassium dihydrogen phosphate, 8·5 ml. *M*/2 disodium hydrogen phosphate, 240 ml. 0·9 per cent sodium chloride, glucose *M*/100) and resuspended in an equal volume of the same medium. After preliminary incubation to allow complete oxygenation, samples were taken for measurement of the initial potassium and sodium contents of the cells and lactic acid content of the medium. Replicate samples were then incubated (37° C.) for 2 hr. in a Warburg apparatus with air as the gas phase, when final estimations of potassium, sodium and lactic acid content were again made. Potassium and sodium were measured directly from centrifuged cells using a Beckman flame photometer; lactic acid contents of the media were measured by the method of Barker and Summerson[4].

The results are shown in Tables 1 and 2. Within the period 12–60 days of age, in each of the lambs used, large decreases in red cell potassium content were observed whereas the sodium content rose appreciably. Uptake of oxygen by the red cells decreased with increasing age of the lambs but no regular trend was observed with respect to lactic acid production by the same cell samples. Incubation in the presence of iodoacetate resulted in great reduction in the lactic acid production without change in the cell potassium content. In anaerobic conditions (oxygen-free nitrogen as gas phase and chromous chloride in centre wells of flasks), however, the red cells lost an average of 17 per cent of their potassium in 3 hr.

Table 2

Lamb No.	Age (days)	Incubation conditions	[Na+] (m.equiv./l.) Initial	[Na+] (m.equiv./l.) Final	[K+] (m.equiv./l.) Initial	[K+] (m.equiv./l.) Final	Qlactic acid
1	14	Control	79	77	44	44	0·44
		0·001 *M* IAA	79	79	44	46	0
2	14	Control	86	85	44	41	0·42
		0·001 *M* IAA	86	87	44	39	0·02
3	14	Control	81	76	46	46	0·33
		0·001 *M* IAA	81	81	46	47	0·01
4	14	Control	84	84	42	48	0·37
		0·001 *M* IAA	84	84	42	42	0
1	14	3 hr. N_2 + 0·001 *M* IAA	87	89	43	36	0·04
2	14	3 hr. N_2 + 0·001 *M* IAA	53	58	83	67	0·02
3	13	3 hr. N_2 + 0·001 *M* IAA	90	91	49	43	0·02
4	12	3 hr. N_2 + 0·001 *M* IAA	74	86	53	41	0

Thus there appears to be little correlation between the potassium retention and glycolysis, but rather more between oxidative metabolism and maintenance of the potassium content of the cells.

Consideration of the changes observed in intracellular potassium concentration with age compared with the concomitant changes in total metabolic activity indicates that while decreases in potassium concentration of the order of 90 per cent occurred, oxygen usage declined to about half, and glycolytic activity to a slightly less extent.

Thus it is suggested that red blood cell suspensions such as these, in which large changes in intracellular potassium and sodium concentrations occur naturally, may provide more suitable material for investigations attempting to relate potassium retention to other cellular characteristics. Particularly indicated are studies involving the use of radioactive potassium, which is not available in sufficient activity in Australia, to estimate the degree of dependence of potassium transport and concentration on the metabolic activity of lamb red blood cells.

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Serum Lipoproteins and Blood Coagulation

Inhabitants of the highlands of New Guinea eat very little fat in their diet, have low levels of serum cholesterol, and rarely suffer from coronary heart disease[1]. This is in accord with experiences in other primitive races, and contrasts sharply with what is found among Australians and others of European origin, thus providing indirect support for the lipid infiltration theory of atherogenesis. With the thrombogenic theory in mind it would be valuable to gather information about coagulability of blood in different races, and this, to a limited extent, has been done in Australia and New Guinea.

Observations show that blood clots faster in natives than in Australians. The average whole-blood clotting times measured in duplicate in siliconed glass tubes were 26·6 and 28·6 min., respectively ($P < 0·01$), and the Stypven times (recalcified platelet-poor plasma accelerated with Russell's viper venom) were 41·4 and 72·2 seconds ($P < 0·001$). There was no significant correlation between these two clotting tests, and neither bore any relation to the levels of serum cholesterol or phospholipids. However, further analysis suggested that Stypven times were markedly affected by the serum lipoproteins. This was the case in both the aborigenes and Australians (40 and 26 men respectively) and accounted in part for the overall difference between the two racial groups. The lipoprotein fractions were measured as milligrammes of cholesterol eluted from paper strips after electrophoresis[2]. The partial correlation coefficient for Stypven time and alpha-cholesterol was positive and highly significant: on the other hand, the coefficient for Stypven time and beta-cholesterol was negative

but not significant. The regression relationships were as follows: Stypven time (sec.) $= 50{\cdot}51 + 0{\cdot}80\alpha - 0{\cdot}8\beta$ for the Australians, and $40{\cdot}32 + 0{\cdot}46\alpha - 0{\cdot}09\beta$ for the natives.

The results offer no direct support for a thrombogenic factor in coronary heart disease, but they do suggest that a constituent of alpha-lipoprotein delays clotting in the Stypven test. Whatever may be the nature of this inhibiting factor, there is evidence to suggest that it is not cholesterol itself[2]. In order to confirm these observations further study of the effects of the specific phospholipid and fatty acid constituents of alpha-lipoprotein on the Stypven system will be necessary.

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Effect of Diphosphopyridine Nucleotide on the Inhibition of Rat Liver 3-Hydroxyanthranilic-Acid Oxidase by 2-Acetylaminofluorene and N-2-Fluorenyl-diacetamide

Dunning *et al.*[1] demonstrated that bladder cancer due to 2-acetylaminofluorene was produced in almost all rats (strain Fisher 344) on a diet containing large quantities (1·4–4·3 per cent) of tryptophan. On the other hand, rats on a diet containing smaller amounts of tryptophan did not develop bladder cancer. We showed that the administration of 2-acetylaminofluorene inhibits 3-hydroxyanthranilic-acid oxidase in rat hepatic tissue[2], with consequent accumulation of the two carcinogenic *o*-aminophenolic compounds 3-hydroxyanthranilic acid and 3-hydroxykynurenine[3]. It seemed of interest to pursue these studies in order to elucidate the mechanism of this inhibition.

Kielley[4] has demonstrated that several carcinogenic fluorene compounds inhibit glutamic dehydrogenase; N-2-fluorenyl-diacetamide would therefore act by blocking the utilization of diphosphopyridine nucleotide[5]. In view of this, it seems probable that 2-acetylaminofluorene inhibits 3-hydroxyanthranilic-acid oxidase by affecting the utilization of diphosphopyridine nucleotide (which seems to take part in the reaction[6]). In order to test this hypothesis, we performed new experiments with 2-acetylaminofluorene and N-2-fluoroenyldiacetamide.

Livers, from rats of unspecified strain weighing about 200 gm. and which had received 0·1–0·2 per cent of Hoffmann–La Roche 2-acetylaminofluorene in their diet (Coward) for 2–6 days, were used. The liver was excised, immediately homogenized in the cold in a Potter blendor with Krebs–Ringer phosphate (3 ml. per gm. of tissue), and centrifuged. The supernatant was used as enzyme source.

The incubation mixtures had the following composition: 1 ml. of supernatant; 3,000 μgm. 3-hydroxyanthranilic acid (Hoffmann–La Roche) diphosphopyridine nucleotide (I.S.I.) at a final concentration of 2×10^{-4} *M* (made up to final volume of 6·34 ml. with Ringer's solution). At the same time mixtures without diphosphopyridine nucleotide, without 3-hydroxyanthranilic acid and without tissue were prepared. The mixtures were incubated at 37° C. for 90 min. with frequent shaking.

Quinolinic acid was determined according to the method of Rabinovitz *et al.* with slight modifications[7].

Livers of rats of the same strain, weight and age, which had received the same diet, but without 2-acetylaminofluorene, were assayed for their ability to convert 3-hydroxyanthranilic acid into quinolinic acid under identical experimental conditions.

In one experiment 546 μgm. of quinolinic acid was formed in the presence of normal rat liver (diphosphopyridine nucleotide does not affect this enzymatic activity); 273 μgm. quinolinic acid was formed in the presence of liver from a rat treated with 2-acetylaminofluorene (diphosphopyridine nucleotide added to these incubation mixtures brings the enzymatic activity almost back to normal).

In other experiments we studied the 3-hydroxyanthranilic-acid oxidase activity in rats treated with parenteral injections of N-2-fluorenyl-diacetamide (for which we thank Prof. Kielley and Prof. Weisberger) and the effect of diphosphopyridine nucleotide on this activity *in vitro*. Rats weighing about 200 gm. were treated for four days parenterally with N-2-fluorenyl-diacetamide (40 mgm. in 2 ml. of sterile olive oil per day); on the fifth day the treated animals and the controls, which received 2 ml. of olive oil per day for four days, were killed by decapitation and the 3-hydroxyanthranilic-acid oxidase in the liver determined as described above.

In one experiment 525 μgm. of quinolinic acid was formed in the presence of normal rat liver (diphosphopyridine nucleotide does not potentiate this enzymatic activity); 315 μgm. of quinolinic acid was formed in the presence of liver from a rat treated with N-2-fluorenyldiacetamide (diphosphopyridine nucleotide added to these incubation mixtures brings the enzymatic activity back to normal).

Thus, *in vitro*, diphosphopyridine nucleotide abolished the inhibition of rat liver 3-hydroxyanthranilic-acid oxidase produced by 2-acetylaminofluorene and N-2-fluorenyldiacetamide.

Our work therefore confirms Kielley's[4,5] on the inhibitory influence of fluorene carcinogens on the utilization of the pyridine coenzymes. Moreover, these investigations lead to the following important suggestion: the inhibition of 3-hydroxyanthranilic-acid oxidase is observed both in hepatic tissue of rats bearing Oberling, Guérin and Guérin myeloma at the leukæmic phase[8] and in the hepatic tissue of rats treated with 2-acetylaminofluorene and N-2-fluorenyldiacetamide. In both cases this inhibition is abolished by diphosphopyridine nucleotide.

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A Bucco-hypophysial Canal in *Elops saurus*

A PERSISTENT Rathke's pouch in the form of a hollow bucco-hypophysial canal piercing the parasphenoid bone has been reported in young animals and adults of the two recent brachiopterygian genera *Calamoichthys*[1] and *Polypterus*[2,3]. The recent coelacanthid *Latimeria* is reported to possess a partly hollow cord of glandular tissue running from the adenohypophysis towards the roof of the mouth cavity[4]. Besides, there is a canal in the parasphenoid, but this canal, which is regarded as a vestige of Rathke's pouch, does not reach the fossa hypophyseos[5]. In the early fossil coelanthids the fossa hypophyseos is in communication with the mouth cavity by means of a canal piercing the parasphenoid and the same is true of the Devonian rhipidistid crossopterygians[6]. In the fossil actinopterygians this communication is rarely retained and has been observed in a few instances only[7–9]. In the recent actinopterygians it has been hitherto unknown.

It was very surprising, therefore, to find a wide canal connecting the pituitary and the oral epithelium in young individuals of the primitive teleost *Elops saurus* (Fig. 1). No doubt this canal, which strongly resembles that of *Polypterus*, represents a rudiment of the original pharyngeal pouch.

The canal originates at the anterior end of the adenohypophysis from several follicle-like pockets, which contain tall cells, apparently with glandular properties. In its proximal part, the canal is directed straight ventralwards until it reaches the parasphenoid. There the lumen becomes narrower and the canal turns at right angles rostrally and slightly ventrally, before passing obliquely through the parasphenoid. Underneath this bone the canal opens into the pharynx as an elongated but rather narrow cleft.

The bucco-hypophysial canal is lined by a single-layered squamous epithelium, which nowhere carries cilia, in contrast to the condition in *Polypterus*, where a strongly ciliated region is found around the opening into the pharynx. The whole apparatus strongly suggests a mechanism for external secretion; but no trace of secretion could be seen in the canal lumen of the specimens investigated.

Fig. 1. *Elops saurus*, 60 mm. median section through the pituitary region showing: *a*, adenohypophysis; *b*, blood vessel; *c*, bucco-hypophysial canal; *i*, infundibulum; *n*, neurohypophysis; *o*, canal opening into the pharynx; *p*, parasphenoid

There can be scarcely any doubt that the existence of a persistent communication between the pituitary and the roof of the pharynx is an archaic feature, which may possibly even recall the condition in the ascidians[10]. Anyhow, this observation further strengthens the opinion[11] that the members of the family Elopidae are the most archaic of the recent teleosts. At the same time it recalls the recent suggestion[12] that the elopids are holosteans rather than teleosts.

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Soluble Nucleotides and Nucleotide–Amino-Acid Compounds of Yeast

AN investigation of the soluble nucleotides in food yeast (*Torulopsis utilis*) has shown that a complex metabolic pool of these compounds is maintained in growing cells. Marked changes in the size and composition of this pool under different physiological conditions indicate that the metabolism of nucleotides is closely related to the biosynthesis of nucleic acids and proteins. Some evidence has been obtained that, in exponentially growing cells, certain of the nucleotides occur in combination with amino-acids or simple peptides.

Soluble nucleotides were extracted from yeast by means of ice-cold 60 per cent ethyl alcohol. After removal of the solvent by evaporation *in vacuo*, and filtration to free the extract from lipid material, the nucleotides were separated by column chromatography on the basic exchange resin 'Dowex-1' (× 10). The general method of preparation and operation of the column followed that of Brumm, Potter and Siekevitz[1], except that the elution gradient was steepened by reducing the mixing volume in two stages. In this way, improved separation and sharper peaks were obtained in the later stages of elution. A typical example of the separations achieved by this method is shown in Fig. 1. Identification of the nucleotide peaks is based on co-chromatography with pure compounds, where available, and on measurements of ultra-violet absorption spectra under acid and alkaline conditions.

The elution pattern shown has been consistently observed when cells, in the exponential phase of growth, were rapidly separated from the culture medium by filtration and immediately treated with ice-cold absolute alcohol. Prompt harvesting and fixation are important, since otherwise marked changes occur in the nucleotide pool. For example,

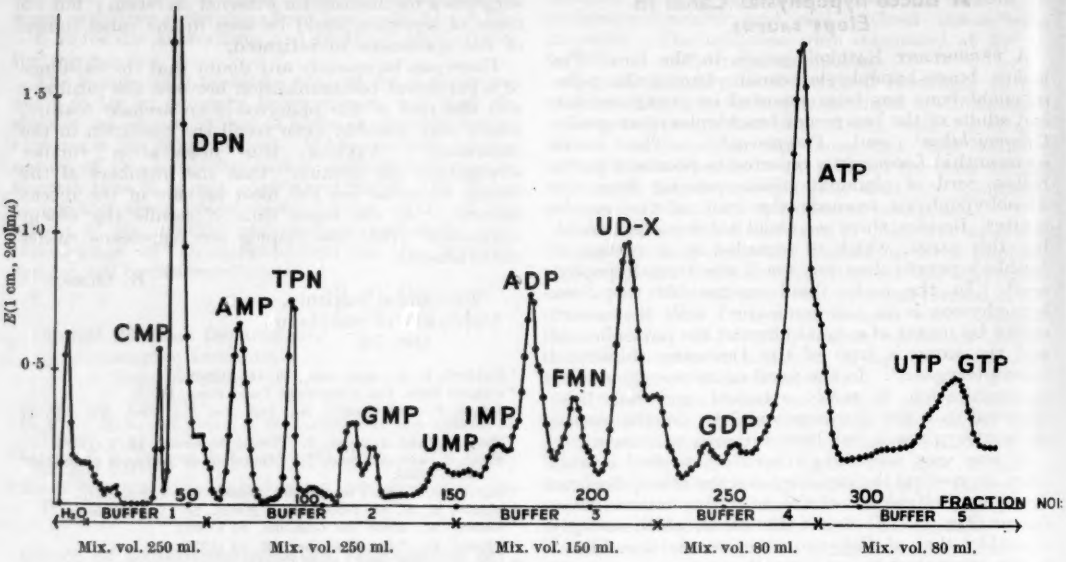

Fig. 1. Soluble nucleotides of *Torulopsis utilis*. Extract from 1·56 gm. fresh yeast eluted from 'Dowex-1' (formate) 200–400 (×10); column 16 × 1·5 cm.; fractions 3·7 ml. Buffers: (No. 1), 1 *N* formic acid; (2), 4 *N* formic acid; (3), 4 *N* formic acid – 0·2 *M* ammonium formate; (4), 4 *N* formic acid – 0·4 *M* ammonium formate; (5), 4 *N* formic acid – 0·8 *M* ammonium formate.

AMP, ADP, ATP, adenosine 5′ mono-, di- and tri-phosphates; UMP, UDP, UTP, uridine 5′ mono-, di- and tri-phosphates; GMP, GDP, GTP, guanosine 5′ mono-, di- and tri-phosphates; CMP, cytidine 5′ monophosphate; IMP, inosine 5′ monophosphate; DPN, TPN, di- and tri-phosphopyridine nucleotides; FMN, flavin mononucleotide

cells harvested less rapidly by centrifugation contain much larger quantities of the monophosphates inosine 5′ monophosphate and uridine 5′ monophosphate.

The composite peak, uridine 5′ diphosphate-*X*, has only been found in extracts prepared from exponentially growing cells; it undergoes a sharp decline if the culture is harvested by centrifugation. Examination of the peak has shown that on hydrolysis with 1 *N* acid it yields four amino-acids, which have been identified by column and paper chromatography as aspartic acid, glutamic acid, arginine and alanine. It has not been possible to separate the nucleotide and amino-acid components by purification on the acidic resin, 'Zeokarb 225', on charcoal, or by paper electrophoresis.

A more thorough investigation of the uridine 5′ diphosphate-*X* peak is now in progress, and an attempt is being made to estimate the rate of turnover of the constituent amino-acids by means of substrates labelled with carbon-14. Thus more decisive evidence may be gained of the significance of these constituents in the synthesis of peptides and proteins in yeast and of their relation to similar nucleotide compounds which have been detected in other micro-organisms[2–5].

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Root Nodules in *Discaria toumatou*

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Discaria toumatou is a thorny shrub belonging to the Rhamnaceae. It is endemic in New Zealand and is common in mountain valleys on the eastern side of the Southern Alps. The root systems of plants growing in a number of widely separated localities in the South Island have been examined and all have been found to be nodulated.

Fig. 1 shows the nodules which by continuous dichotomous branching give rise to coralloid clusters. Morphologically they have a number of features in common with previously described non-leguminous nodules[1]. They represent modified roots, in which there is no distinct apical meristem and with many of the cortical cells enlarged and occupied by an endophyte. In infected cells immediately below the apex the endophyte appears to be filamentous. Sections cut farther down show that the endophyte produces bunches of vesicles approximately 4μ in diameter. In fresh preparations mounted in water, these bunches can be freed from the host cells by squashing and some of the vesicles become detached together with a short length of hypha-like connecting strand. Nuclei in infected cells are large and misshapen. In the basal regions of the nodule branches there is a zone in which the contents of the infected cells are more amorphous and appear to be undergoing degeneration.

The taxonomic position of *Discaria* in relation to other genera with root nodules is of interest. In the Rhamnaceae, there is another genus, *Ceanothus*, known to have nodules. All three genera of the Eleagnaceae have been found nodulated and Hutchinson[2] places this family together with the Rhamnaceae in a common order, the Rhamnales. This group, then,

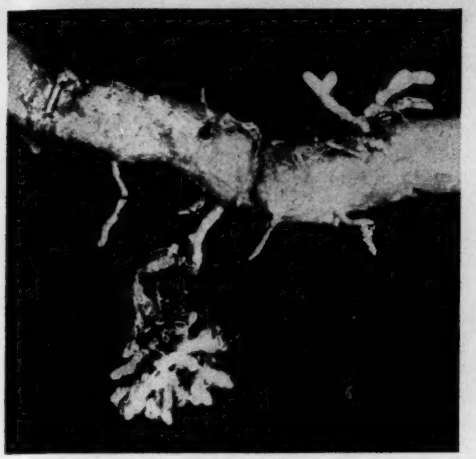

Fig. 1. Nodules on *Discaria toumatou*. (Actual size)

contains five of the nine non-leguminous dicotyledonous genera which have been reported to bear nodules of the general type described here.

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Application of Autoradiographic Techniques to Studies of Shoot Apices

In contrast to the earlier widely accepted concepts of the structure and growth of the shoot apex, Buvat and his associates[1-3] have proposed an alternative interpretation. According to this newer view the most apical, axial cells of shoot apices in a variety of plants do not have histogenic or organogenic roles during vegetative growth. The criterion of activity was based on the frequency of mitosis. This information was obtained by counting mitotic figures in various zones of the shoot apex and then presenting this information in the form of a composite diagram. The results of these investigations have been challenged by Gifford[4] and by Popham[5]; the latter used essentially the same methods as did the French workers.

It would seem, then, that more definitive evidence is necessary before any final conclusions can be drawn. The existing results are limited largely by the techniques used. The simple counting of division figures as an indication of local frequencies of mitotic activity has several drawbacks, including possible periodicity, either local or general. Also, mitotic frequency diagrams are meaningful only if the cell size is relatively uniform in the areas which are being compared. However, this is not the case in shoot apices. Therefore, new techniques must be applied to a more thorough analysis of the problem.

A suggestion of a new approach came from the recent work of Clowes[6] on the localization of nucleic acid synthesis in root meristems by using autoradiographic techniques.

In our present investigations we have applied the autoradiographic localization of nucleic acid synthesis to shoot apices, using phosphorus-32 in the form of inorganic phosphate as the labelling substance. Several plant species were exposed to concentrations of phosphorus-32 ranging from 10 to 50 μc./ml. by immersing either the cut terminal portions (approximately 6–8 in. long) or the roots of the intact plants in Hoagland's solution with phosphorus-32 added, for periods of 1–7 days. Shoot tips were then fixed in formalin–acetic alcohol, dehydrated, embedded in paraffin and sectioned at 8–10μ. Using high-resolution stripping film ('Kodak' Fine-Grain Autoradiographic Stripping Plate *AR*. 10), the technique as outlined by Taylor and McMaster[7] was employed. The prepared autoradiographs, in which the sections and the film are permanently superimposed and in register, were mounted in an oil with a refractive index approximating that of the unstained sections, thus minimizing the light scatter by the section while the autoradiographic image was photographed by dark-field illumination. Then, without changing the stage setting of the microscope, xylol was injected under the coverslip to lower the refractive index of the mounting medium, thus producing a more intense phase-contrast image to permit the photographing of the section.

In this preliminary report we shall confine our observations to just one of the species investigated-namely, *Pinus lambertiana*. Fig. 1 shows the phase-contrast image of a median longitudinal section of the shoot apex and Fig. 2 the corresponding autoradiograph. This shoot was exposed to phosphorus-32 solution for a period of three days, and the section was extracted according to the schedule of Taylor and McMaster, using finally a hydrolysis in *N* hydrochloric acid at 60° C. for 12 min. to remove the ribonucleic acid. After this treatment the major part of the radioactivity is due to the phosphorus-32 incorporated into newly synthesized deoxyribonucleic acid, with some possible activity in proteins.

Cytological zonation of the apex is evident in Fig. 1, namely, a terminal zone (I) consisting of large vacuolate cells with correspondingly large nuclei, a peripheral zone (II) of smaller cells and a central column of rib meristem (III). For convenience of presentation, zone I includes apical initials and central mother zone, an organization frequently recognized by others. According to the French workers the site of intense mitotic activity is in the upper portion of the peripheral zone, which they assume to be self-perpetuating, with little or no activity in the terminal zone. Although no division figures are evident in Fig. 1, there is evidence of synthesis of deoxyribonucleic acid, as shown in Fig. 2. Some of these centres of high radioactivity, as indicated by the dense clusters of silver grains, clearly fall within the terminal zone. These centres can be seen to coincide with nuclei in Fig. 1. There are certain highly refractive areas in the developing pith and in the leaves which over-arch the apex; these are not to be confused with light scatter due to exposed silver grains in the emulsion.

The presence of synthesis of deoxyribonucleic acid, as evidenced by the incorporation of radioactive label, can be taken to be indicative of subsequent mitotic activity, in the absence of metabolic turnover of deoxyribonucleic acid or the occurrence of endo-

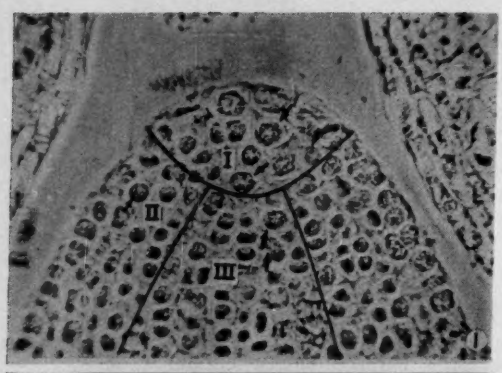

Fig. 1. Longitudinal section, shoot apex of *Pinus lambertiana* (phase-contrast image) showing cytological zonation, that is, zone I, terminal zone; zone II, peripheral zone; zone III, rib meristem. Arrows indicate nuclei which incorporated large amounts of phosphorus-32 into deoxyribonucleic acid

Fig. 2. Autoradiograph of same section (photographed with dark-field illumination). Centres of radioactivity, indicated by arrows, coincide with nuclei indicated in Fig. 1. Scattering of light, due to refractiveness of certain cells and/or damage to the photographic emulsion, is evident near the tip of the apex, in young leaves, and in developing pith cells, but does not represent radioactivity. (Both figures × 210)

mitotic reduplication. The very presence of these highly radioactive centres within the bounds of the terminal zone would indicate that these nuclei do divide since the alternative sequels to synthesis of deoxyribonucleic acid can very likely be ruled out. If the French workers were correct in their interpretation, the centres of high activity would be immediately below the line separating the terminal and peripheral zones, but not in the terminal zone.

Autoradiographs (not shown here) showing total nucleic acid synthesis (deoxyribonucleic acid plus ribonucleic acid) indicate a rather high level of activity which appears to have a relatively uniform distribution throughout the apex. However, it should be pointed out that owing to such complicating factors as 'background activity', which is more or less uniformly distributed in the emulsion, subtle differences of degree of activity as well as its total absence are difficult if not impossible to demonstrate by these means.

At the present stage of these investigations it would seem that the observations made here for *Pinus* would apply generally to the other species examined, which include *Glycine max*, *Chenopodium alba* and *Ginkgo biloba*. A more extensive report of these observations will be published later.

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Induced Apospory in Polypodiaceous Ferns

The induction of outgrowths of gametophytic tissue from the sporophyte in mosses has been accomplished many times since Pringsheim[1] first reported it. In the ferns, the aposporous production of fully sexual gametophytes from genetically normal sporophytes has been considered to occur less readily. Although various forms of apospory in a number of ferns have been reported by Goebel[2] and others, the only well-investigated example of its induction and consequences is in *Osmunda*, where apospory was induced by continued maltreatment and malnutrition of the sporeling[3].

Recent experiments have shown that apospory can be regularly induced in normal sporelings in at least two other species of fern, namely, *Thelypteris palustris* and *Pteridium aquilinum*. Sporelings were raised from gametophytes grown in pure culture from spores from wild populations of these ferns. The first or second leaves of the sporelings were detached when fully expanded and placed on sterile mineral – agar slopes, a small square of glass being used to press a portion of each lamina close to the medium. With only one exception (where the leaf died) in numerous experiments, filaments have grown out from the margin or surface of the leaf (Fig. 1). The filaments eventually gave rise to cordate gametophytes. In *Thelypteris* it was afterwards found that leaves up to at least the tenth continued to show this phenomenon.

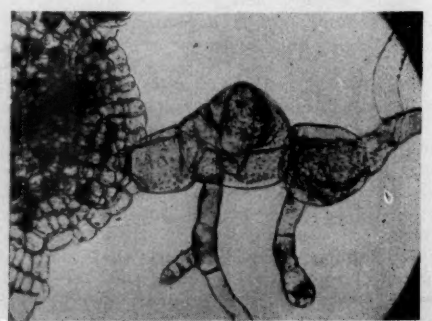

Fig. 1. *Pteridium aquilinum*. Filament growing out from marginal cell of the first leaf of a normal sporeling detached and placed on agar. (× 150)

It was considered possible that sporelings giving rise so readily to gametophytic tissue were abnormal, but no evidence could be found in support of this view. The sporelings arose after controlled fertilization and had every appearance of being produced by the normal sexual means. Furthermore, the development of the sporelings after the removal of the leaves for experimentation showed no peculiarities.

Additional evidence in favour of the normality of the intermediate sporelings was obtained by comparing the amount of deoxyribonucleic acid in the nuclei of the gametophytes produced aposporously with that in the nuclei of the original. Specimens of both sets of gametophytes were fixed, sectioned, and the sections stained simultaneously in Feulgen's reagent according to Partanen's schedule[4]. The intensity of the staining was measured with a scanning microspectrophotometer built by Deeley[5]. The results are shown in Fig. 2. As expected, the amounts of deoxyribonucleic acid in the nuclei of the two sets of gametophytes are in the ratio 2 : 1. Some estimates were also made of the deoxyribonucleic acid in the nuclei of a young crozier from one of the sporelings. Because of the harder cell walls, few nuclei in these sections could be satisfactorily flattened for scanning, but the results obtained fully support the normality of the sporeling.

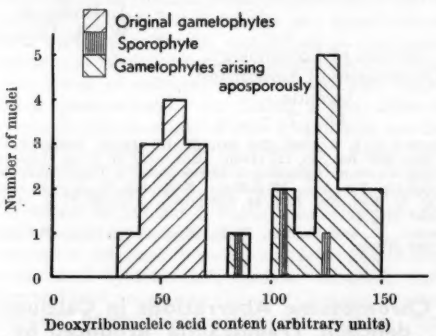

Fig. 2. *Thelypteris palustris*. Amounts of deoxyribonucleic acid in nuclei of normal gametophytes, a normal sporeling and gametophytes arising aposporously

It can be concluded, therefore, that by the technique reported here, outgrowths of gametophytic tissue can be obtained readily from the sporophytes of two species of polypodiaceous ferns without the intervention of meiosis. Gametophytes obtained in this way have produced sex organs, and sporelings raised from them are the subject of further study. There seems no reason why the technique should not be generally applicable in the ferns.

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Symptoms of Calcium and Phosphorus Deficiency in Oil Palm Seedlings

Previous attempts[1,2] to induce symptoms of calcium and phosphorus deficiency in oil palm seedlings grown in water-washed quartz sand have failed. Symptoms have now been induced by growing oil palm seedlings in quartz sand purified by treatment with hot 1 per cent sodium carbonate and hot, constant-boiling hydrochloric acid.

The experimental methods used were based on those recommended by Hewitt[3] for critical work on nutrient deficiencies. Quartz sand obtained from a local riverine deposit was substantially freed from clay and organic matter by digestion in a Kestner apparatus[3] for two successive 4-hr. periods followed by a third digestion for 3 hr. with hot, constant-boiling hydrochloric acid. Free acid was removed by leaching with de ionized water derived from mixed-bed ion-exchange columns. The specific conductivity of this water was $0{\cdot}3 \times 10^{-6}$ mho cm.$^{-1}$ at 27° C. Adsorbed hydrogen ions were displaced by leaching with 0·02 *M* magnesium nitrate until the *p*H of the effluent exceeded 5·5. In calcium- and phosphorus-deficient nutrient solutions, sodium was substituted for calcium and sulphate for phosphate respectively. Iron was supplied as iron-ethylenediamine tetraacetic acid at a concentration equivalent to 5 p.p.m. ferric iron. In all other respects the nutrient solutions employed were identical with those used at Long Ashton[3]. Seedlings which had been grown in soil for the first two months from germination were transplanted to pure sand in bitumen-lined glazed porcelain pots in late April, and symptoms first appeared during early August.

Phosphorus Deficiency. The first symptom of this disorder was a general reduction in growth and vigour as compared with the complete nutrient control treatment. The oldest leaves became dull and assumed a pale olive-green colour (Munsell Color Fan 2·5*GY* 5/5). As the severity of the deficiency increased emerging leaves became progressively more chlorotic (Munsell 2·5*GY* 6/8) and terminal necrosis appeared on the oldest leaves. Necrotic areas were in general dark brown but their colour was somewhat variable. Where the necrosis developed rapidly, affected tissues were light brown (Munsell 5*YR* 4/5–3/3), but more usually the necrotic areas became blackish-brown or purplish-brown in colour. No

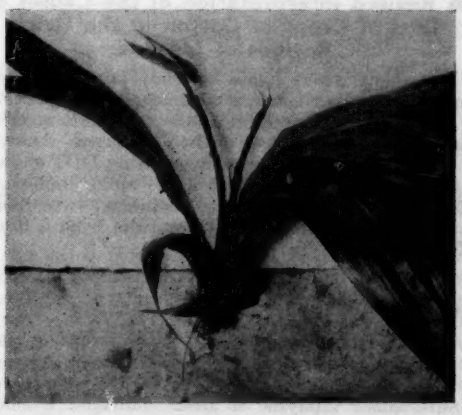

Fig. 1. A seedling deficient in calcium. The central leaves are malformed

obvious chlorotic band separated necrotic from healthy tissues when affected leaves were examined in reflected light. Examination in transmitted light revealed a pale band of tissue, with a water-soaked appearance, at the proximal limit of necrosis. This band was narrow, being about 2–3 mm. wide and yellow in colour (Munsell 10*Y* 6/7). These symptoms suggest that in phosphorus-deficient leaves collapse of cells occurs rather abruptly. Interveinal ochre spots (Munsell 7·5*Y* 6/7) were occasionally present near leaf margins but their significance is obscure. In phosphorus-deficient seedlings leaves are reduced in size and the plastochrone is increased.

Calcium Deficiency. The first characteristic symptom of this disorder was the appearance of a leaf which was abnormally short, narrow and rigid with prominent veins (Fig. 1). In slightly older leaves, which are normally bipinnate in form, one-half of the leaf blade was often narrower than the other with apical splitting and some terminal necrosis. As the deficiency became more severe, there was a progressive reduction in the area of emerging leaves; this reduction exceeded 90 per cent in the leaves most malformed. Terminal necrosis became more severe and ultimately the leaves produced comprised merely the basal part of the petiole. Intermediate leaf shapes occurred in which the leaf blade was truncated and spatulate or strap-shaped with a slight apical indentation. No chlorosis was observed in association with the morphological changes described. Abnormal leaves were dark green (Munsell 5*GY* 4/3) and identical in colour with leaves of control plants receiving a complete nutrient solution.

These observations were made on a large experiment investigating macronutrient deficiency symptoms in seedling oil palms, and the results of this experiment will be published in greater detail elsewhere.

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A Revised Interpretation of the Causes of Loss of Crops of Cotton in the Drier Regions of Uganda

For many years *Lygus vosseleri* Popp. has been considered to be the major cotton pest in Uganda[1].

Recent work at Serere in eastern Uganda suggests that this may not be true of the drier areas. Analysis of a large insecticidal experiment using DDT showed that a high degree of control of 'spiny bollworm' (*Earias* spp., Lepidoptera, Noctuidae) was being obtained, as illustrated by the results from a flower bollworm count (Table 1).

Table 1

Applications of DDT	Damaged flowers	
5	43	*L.S.D.*
3	109	at 5 per cent $P > 0.01$
1	172	62·6
Control	204	

Subsequent analysis of sheds damaged by bollworm (which can be shown to be mainly due to *Earias* spp.) from this and many previous experiments showed that control of *Earias* by DDT has been achieved over many years but had escaped notice due to a preoccupation with efforts to correlate increases of yield with *Lygus*.

It has been impossible to correlate the assessment of any form of damage by *Lygus* with subsequent increases in yield, but highly significant correlations are obtained with all measures of bollworm infestation.

Laboratory work has shown that *Earias* larvæ are capable of doing very severe damage to young cotton plants, removing many small fruiting points, 'tattering' leaves and boring into the growing points. In fact, at this stage of growth of the plants, *Earias* is not a true 'bollworm' but is a general feeder on fruiting points and growing points. The larvæ wander extensively over the plant and, at this stage, no single boll is large enough to sustain a larva through to maturity. It is suggested that this allows considerable pick-up of DDT, especially in the younger instars, resulting in the observed control. So far as can be ascertained, this would appear to be the first recorded case of economic control of *Earias* spp. with DDT on cotton.

The spraying practice now being advised for peasant cotton[2], originally directed against *Lygus* which is probably not responsible for the bulk of the damage, is giving adequate protection against *Earias*.

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Chromosome Aberrations in Calcium-deficient *Tradescantia* produced by Irradiation

The lack of calcium in *Tradescantia* microspores and in barley seeds has been demonstrated to increase the frequency of X-ray-induced chromosome aberrations above similarly irradiated material grown with optimal calcium[1,2]. Mechanisms by which the lack of calcium could cause such an effect have been discussed[1]. It is necessary to distinguish between two important alternatives: (1) does the absence of calcium confer a unique instability on chromosomes as observed by increased breakage, or (2) is the mechanism of increasing breakage more indirect? A likely possibility in the latter category could involve low or high viscosity of the nucleoplasm. Calcium, potassium, sodium, magnesium and manganese are reported to influence viscosity to various degrees[3]. If the increased chromosome sensitivity to radiation acts by a change in viscosity, then metals other than calcium should have similar effects. Previously, magnesium and manganese have been shown to have no effect on modifying the frequency of chromosome aberrations by X-rays[1]. Sodium is not usually an essential element in plants. Potassium is considered here in experiments with *Tradescantia*.

In an extensive series of experiments with various plant species Lundegardh and others[4] have demon-

strated a reciprocal relationship between potassium and calcium. As a rule in nutrient culture when potassium concentration is low and calcium is optimal, then more calcium accumulates in leaves and flowers than potassium as determined by flame photometry. High potassium in the nutrient solutions greatly reduces the movement and accumulation of calcium above the roots. In the latter instance potassium accumulates in the upper part of plants in high concentrations.

The methods have been described by which inflorescences of *Tradescantia paludosa* were cultured and irradiated[1]. As seen in Table 1, limiting potassium in water culture has little or no effect on the frequency of chromosome interchanges. At the lowest concentration of potassium (2·4 p.p.m.) interstitial deletions were significantly lower than controls. When calcium was limiting, both interchanges and interstitial deletions were 40 per cent higher than controls. Thus, calcium seems to be the key metal effecting radiosensitivity.

Nilan and Phillips[2] have recently reported experiments with barley seeds collected from plants grown on low calcium. Twice as many chromosome aberrations were produced in X-rayed seeds lacking calcium as in X-rayed seeds with optimal calcium. There were no differences in aberration frequency between the two levels of calcium when thermal neutrons were employed. These latter results are expected since proton and alpha tracks can break a chromosome whether it is labile or not. *Tradescantia* microspores at two levels of calcium were treated with sparsely ionizing gamma-rays. In Table 2 the differences between treatments are of the magnitude produced by 250 kVp. X-rays (Tables 1 and 3). Hard X-rays and gamma-rays have similar properties in respect to their ion densities[5]. A more labile chromosome would be expected to exhibit a higher sensitivity to these sparsely ionizing radiations.

Factors which modify radiosensitivity (for example, cysteine and cysteamine[6], carbon dioxide[7], carbon monoxide[8] and potassium cyanide[9]) are almost always dependent upon the presence of oxygen during irradiation. In the following experiment pre-purified nitrogen was used to X-ray inflorescences in absence of oxygen. A special 'Lucite' chamber was employed. Three evacuations and three nitrogen flushings were made before irradiation. From Table 3 we see that cells irradiated in nitrogen have about the same increase in sensitivity as cells treated in air. Apparently the influence of limiting calcium on chromosome breakability is independent of oxygen.

The results are compatible with the general hypothesis that chromosomes are inherently more sensitive to breakage at reduced levels of calcium. The increased radiosensitivity appears either in the presence or absence of oxygen. The evidence indicates that lowering the calcium concentration increases the sensitivity to radiation by raising the probability of a sparse track breaking a chromosome. Presumably fewer ionizations can cause a break.

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Table 1. A DOSE OF 400 R. OF 250 KVP. X-RAYS WAS GIVEN AT 100 R. PER MINUTE WITH 1 MM. ALUMINIUM AS FILTRATION

Treatment	p.p.m.		Interchanges No.	Interchanges Per cell	Interstitial deletions No.	Interstitial deletions Per cell	Total cells
Control	250 195	Ca^{++} K^{+}	394	0·71	365	0·66	552
—K	4·9 250	K^{+} Ca^{++}	398	0·80*	326	0·66*	497
—K	2·4 250	K^{+} Ca^{++}	421	0·68*	330	0·53†	620
—Ca	2·1 195	Ca^{++} K^{+}	190	1·02‡	185	1·00‡	186

* Not significantly different from controls, $P > 0·05$ by χ^2 test.
† Significantly different, $P < 0·01$.
‡ Significantly different, $P < 0·001$.

Table 2. 400 R. of GAMMA-RAYS FROM COBALT-60 GIVEN AT 2,400 r. PER MINUTE

Treatment	p.p.m. Ca^{++}	Interchanges No.	Interchanges Per cell	Interstitial deletions No.	Interstitial deletions Per cell	Total cells
Control	250	285	0·71	310	0·78	400
—Ca	6·2	183	0·72*	243	0·96*	254
—Ca	4·2	465	0·74*	698	1·10†	632

* Not significantly different from controls, $P > 0·05$.
† Significantly different, $P < 0·001$.

Table 3. THE 250 KVP. X-RAYS WERE GIVEN AT 50 R. PER MINUTE WITH 1 MM. COPPER AND 1 MM. ALUMINIUM AS FILTRATION

Treatment		p.p.m. Ca^{++}	Interchanges No.	Interchanges Per cell	Interstitial deletions No.	Interstitial deletions Per cell	Total cells
1,000 r. in nitrogen	Control	250	750	1·13	949	1·42	666
	—Ca	6·2	467	1·16*	791	1·97†	402
	—Ca	4·2	705	1·38†	933	1·82†	511
400 r. in air	Control	250	417	0·64	416	0·64	652
	—Ca	6·2	231	0·71*	341	1·05†	324
	—Ca	4·2	261	0·71*	258	0·70*	369

* Not significantly different from control by χ^2 test, $P > 0·05$.
† Significantly different from controls, $P < 0·001$.

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Use of Artificially Liberated Larvæ in Experiments on the Setting Behaviour of *Spirorbis*

DURING a study of the systematics of the Spirorbinae (Serpulidae), it became clear that several forms are found characteristically on specific substrata. Whereas *Spirorbis borealis* Daudin occurs most abundantly on the brown alga *Fucus serratus*, *Spirorbis tridentatus* Levinsen (usually regarded as an ecophenotype of *Spirorbis borealis*[1]) is found only on stones and shells in dimly lit places. Another closely related form, which appears to be a distinct species previously confused with juvenile *S. borealis*, has

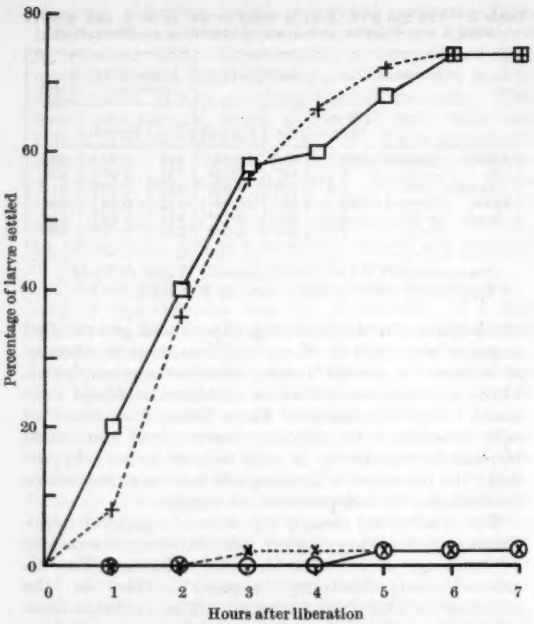

Fig. 1. Settlement of naturally and artificially liberated larvæ of *Spirorbis borealis* on *Fucus serratus* and *Corallina officinalis*. Larvæ settled on *Fucus*: □, naturally liberated; +, artificially liberated. Larvæ settled on *Corallina*: ○, naturally liberated; ×, artificially liberated

been found in the Swansea area only upon the red alga *Corallina officinalis*. Evidently it was desirable to find by experiment whether the larvæ of these forms choose their characteristic substrata.

Spirorbis borealis readily liberates larvæ in the laboratory[2,3]; but the other two forms referred to above do not. Their larvæ could be obtained in large numbers only by breaking the parents' tube and tearing up the chains of advanced embryos that were revealed. Many then hatched or were forced out of their egg capsules and swam towards the light. These larvæ seemed normal in appearance and behaviour. Before using them for experiments, however, larvæ were obtained in a similar manner from *S. borealis*. It was then possible to test the artificially liberated larvæ of this species against larvæ liberated naturally by their parents to see whether they were equally capable of metamorphosis and equally discriminating in their choice of a substratum.

In two parallel series of experiments, naturally and artificially liberated larvæ, in batches of about 25, were put into crystallizing dishes, each containing 100 ml. of sea water and a piece of *Fucus serratus*. After 24 hr., the numbers settled and metamorphosed were 355 out of 455 naturally liberated larvæ (78 per cent) and 229 out of 325 artificially liberated larvæ (70 per cent). The difference is not significant. The percentages are similar to that previously observed when larvæ of this species were presented with bare *Fucus serratus*[4].

In similar experiments, the percentages of larvæ settled were recorded after every hour. Those which had been artificially liberated settled just as early as the others (Fig. 1, upper curves). In parallel experiments pieces of *Corallina officinalis* were used instead of *Fucus* but few larvæ settled upon this alga (Fig. 1, lower curves).

In further experiments larvæ were offered a choice between pieces of *Fucus vesiculosus* and *Corallina officinalis* presented to them in the same dish. It was observed after 24 hr. that out of 200 artificially liberated larvæ, 142 had settled on *Fucus* and none on *Corallina*, whereas out of 200 naturally liberated larvæ 146 had settled on *Fucus* and 5 on *Corallina*.

It therefore appears that artificially liberated larvæ which are capable of swimming are as viable and discriminating in their choice of a substratum as naturally liberated larvæ. It will therefore be possible to use artificially liberated larvæ in experiments on the setting behaviour of other species of *Spirorbis*, particularly of the form which occurs so abundantly on *Corallina*. It seems unlikely that this form on *Corallina* is a young form of *S. borealis* since these experiments show that the larvæ of *S. borealis* do not settle readily on *Corallina*.

Similar methods of obtaining what might be regarded as prematurely liberated larvæ may be useful to workers engaged in anti-fouling research. It seems generally true that the ages at which crises in development occur are not fixed rigidly. Metamorphosis of a variety of planktonic larvæ can be postponed if they fail to find a suitable substratum[5,6]. Barnacle embryos may be retained as embryos by their parents for considerable periods, if there is little food available in the surrounding water[7–9].

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Flash Lighting for Egg Production

The use of artificial lighting to extend day-length to 13–14 hr. is well established in commercial poultry-keeping as a means of stimulating the production of eggs in winter. Weber[1] claimed that similar increases in yield could be obtained by a 'shock-lighting' technique in which two 20-sec. flashes of high-intensity light, administered at 4.00 and 4.45 a.m., were the sole additions to natural winter daylight. Over the past seven years a series of experiments investigating the nature of the response to flash lighting has been carried out at Reading with the aid of funds provided by the Agricultural Research Council, and with the co-operation of the Electrical Research Association. These have confirmed that, although Weber's regime does not give the best results, pullets can be stimulated to high production of eggs by a variety of flash-lighting treatments.

It seemed at one time that flashes of light were quite as effective as normal extended lighting so long as they supplied the same total quantity of illumination—16 lumen hr./ft.^{2}/day—in addition to the natural daylight available. In the winter of 1956–57 a series of treatments, all providing this

Table 1. Flash Lighting Experiment: December 1956—March 1957

Treatment No.*	Wattage of lamps	No. of flashes	Duration of each flash (sec.)	Time of first flash	Interval between flashes	Egg production (eggs/bird/day)
1	1,500	3	20	3.00 a.m.	1 hr.	0·824
2	1,000	5	20	,,	20 min.	0·821
3	750	7	20	,,	15 min.	0·819
4	500	10	20	,,	15 min.	0·818
5	300	18	20	,,	5 min.	0·820
6	1,500	10	6	,,	15 min.	0·804
7	1,000	10	10	,,	,,	0·819
8	750	10	14	,,	,,	0·821
9	500	10	20	,,	,,	0·817
10	300	10	35	,,	,,	0·818
11	60	2	2 hours	(5–7 a.m. : 5–7 p.m.)		0·821
12	—	(Control—winter daylight only)				0·767

* Treatments 1–11 all provided 16 lumen hr./ft.²/day of illumination in addition to daylight from 7.0 a.m. to 5.0 p.m.

Table 2. Flash Lighting Experiment: September 1957—March 1958

Treatment No.	Wattage of lamps	No. of flashes	Duration of each flash (sec.)	Time of first flash	Interval between flashes	Light applied (lumen hr./ft.²/day)	Egg production (eggs/bird/day)
1	—	(Control—winter daylight only)				—	0·549
2	500	10	20	3.00 a.m.	15 min.	16	0·631*
3	1,500	3	20	1½ hr. before sunrise	15 min.	16	0·510
4	300	4–18†	10	14 hr. before sunrise	20 min.	2–8*	0·610*

* Treatments 2 and 4 significantly better than 1 and 3, $P < 0.05$.
† Number of flashes varied to fill the interval between (sunset—14 hr.) and sunrise.

quantity of additional light, but varying widely in the intensity, number and duration of flashes, were tested and gave very uniform results (Table 1). Despite this uniformity, it remained difficult to reconcile the hypothesis of an 'optimum quantity' of light with any satisfactory physiological explanation, especially since the additional illumination is only a fractional increase on the relatively large, and very variable, amount of light provided by a winter day.

Farner *et al.*[2] (studying testicular development in sparrows) have postulated a light-sensitive mechanism capable of activation almost immediately upon the onset of lighting and remaining active for some time during the ensuing darkness. A similar mechanism, affecting the activity (rather than the growth) of the fowl's ovary, would allow an alternative explanation of the flash-lighting effect. If activation commences with a first flash at 3.0 a.m. and is maintained by subsequent flashes until daybreak, then the bird could be said to be 'illuminated' throughout this period. Thus the critical condition for the success of flash-lighting (for laying hens) would be an interval of 13–14 hr. between the first flash and sunset. A recent trial (see Table 2) has shown that the time of application of light can be altered so that it is no longer an effective stimulus (treatment 3); and that a much smaller quantity of light, applied at the right time, is sufficient to produce maximum response (treatment 4). The fact that Weber, working at Berne in Switzerland, found flash lighting from 4.0 a.m. to be satisfactory, whereas at Reading we have demonstrated that it is necessary to start at 3.0 a.m. to achieve results comparable with extended lighting, may be accounted for by the difference in the times of winter sunset at the two latitudes.

We can now argue that flash lighting does not differ in principle from the familiar techniques of poultry-house lighting. Although a satisfactory physiological explanation of the way in which light influences the rate of ovulation is no nearer, it is now possible to include the flash lighting of poultry as yet another aspect of photoperiodism in animals.

To define minimum standards for intensity, duration and number of flashes required to stimulate maximum production of eggs, allowing for possible interactions, would require an extensive series of trials. However, the assumption that 'high-intensity' illumination is required is probably false and a considerably smaller total quantity of light than was used in treatment 4 (shown in Table 2) might well suffice. Since none of the experiments at Reading has shown flash lighting to be superior to the standard 14-hr. day, and since the equipment needed for flashing is rather elaborate and the saving in cost of electricity is unimportant, there is little reason to recommend the use of this technique in practice. In special circumstances where it is necessary to stimulate egg production without encouraging other forms of activity in the bird, flash lighting may be of value.

It has long been assumed that maximum production of eggs in the fowl is attained under conditions of constant day-length, although Whetham[3] questioned this assumption more than twenty-five years ago and King[4] has recently published some evidence suggesting that continuously increasing day-length may be preferable. While we have recently shown[5] that onset of sexual maturity in the fowl is affected by changes in day-length and not by the absolute level of day-length, the problem of the light regime needed to elicit maximum rate of egg laying in the fowl requires separate intensive study. It is not necessarily true, as has sometimes been assumed, that conditions which are most favourable for bringing the gonads into a reproductive state are also the most favourable for maintaining a short interval between successive ovulations.

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Occurrence of *Microsporum gypseum*, *Keratinomyces ajelloi* and *Trichophyton terrestre* in Some British Soils

In recent years many attempts have been made to confirm the belief that dermatophytes have a saprophytic existence in the soil. These investigations have disclosed the widespread occurrence of the pathogenic species *Microsporum gypseum* (Bodin) Brumpt[1-6] and the existence of the saprophytes *Keratinomyces ajelloi* Vanbreuseghem[2,5-7] and *Trichophyton terrestre* Durie and Frey[8].

A preliminary examination of some British soils has been made using the method developed by Vanbreuseghem[9]. The samples were collected by scraping into sterile boiling-tubes. They were then placed in Petri dishes and moistened with sterile distilled water. Short strands of autoclaved human hair were placed on the soil surface and the plates were left at room temperature (approximately 20–22° C.). Visible mycelial growth appeared on the hair in two to four weeks. Small pieces of mycelium and infected hair were transferred to plates of malt agar containing cycloheximide ('Actidione') 0·5 mgm./ml., penicillin 40 units/ml., streptomycin 40 units/ml. and potassium tellurite 0·36 mgm./ml.

The soils were collected from areas in and around Bath, Somerset, where clay on limestone predominates. Thirty samples were examined; of these, seven came from farmland and eleven were garden soils, the remaining twelve being from woodland, parkland, riverside and roadside banks and river gravel.

Results are summarized in Table 1.

Table 1

	Farm	Garden	Others
K. ajelloi only	1	9	1
K. ajelloi + *M. gypseum*	1	1	—
K. ajelloi + *T. terrestre*	3	—	2
Negative for these species	2	1	9

One of the farm soils which yielded *K. ajelloi* and *T. terrestre* contained cow hairs and another contained feathers. The conidia of these species were seen on direct microscopical examination of the disintegrating feathers in the latter sample.

Various other keratinophilic fungi which have not yet been identified were also encountered both in the presence, and in two cases in the absence, of the three known species. The ten soils from which no keratinophilic fungi were isolated included a mole-hill in a pasture, a recently ploughed field, a roadside bank and all the seven woodland soils examined.

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Freemartins in Sheep

With cattle twins of opposite sex the female is in almost all cases infertile and shows varying degrees of masculinity, both in behaviour and in the morphology of the reproductive tract. Such females are known as freemartins. Swett *et al.*[1] consider that the freemartin condition is due to irreversible modification of the female by masculinizing secretions from the male fœtus. It is possible for any such secretions to pass between the two fœtuses as it has been known for some time that the bloods of twin calves are able to mix through anastomoses in the placental vessels[2].

Owen[3] and Owen *et al.*[4] have reported that most dizygotic twin calves are red blood-cell chimæras. They are born with, and often retain throughout life, red cells of dual origin. The same authors argued that since the life of red cells is short, red-cell precursors must be exchanged between the twins via the placental anastomoses during fœtal life and these precursors must establish themselves in the tissues of the opposite twin. It has been shown that the majority of dizygotic twin calves are tolerant to each other's tissues[5]. They will accept homografts of each other's skin, whereas grafts exchanged between calves of the same parentage but born at different times are rapidly rejected.

In a recent study in which attempts were made to induce a state of acquired tolerance in sheep, we used the fate of skin homografts as a criterion to determine if tolerance had been established. In the sheep, skin homografts are normally rejected and die within 10 days of grafting, whereas autografts are accepted by the host[6]. In the course of this study grafts were exchanged between sheep twins of opposite sex; in all, five sets of such twins were involved. Four of the five sets showed normal homograft reactions, the skin dying within 10 days, whereas the homografts on the remaining pair behaved as autografts. At the time of writing these surviving grafts are 245 days old, and both appear quite healthy, each being covered by an excellent growth of wool. The female of this pair shows abnormal development of the vulva and clitoris (Fig. 1), and although now more than two years old has never shown any signs of œstrus. She does in fact appear to be a freemartin.

Freemartins in sheep have only been reported sporadically[7,8]. The observations reported above provide further evidence for the occurrence of freemartins in

Fig. 1. Enlarged vulva and clitoris of female twin

sheep, and they suggest that a state of tissue tolerance may exist between the freemartin and her male twin.

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Automatic Subdivision of Associated Populations

Consideration has been given in the past to the factorial analysis of qualitative data[1], including that particular form in which the attributes (presence-or-absence, yes-or-no) can take only the values 0 or 1, so that the correlation matrix is obtained from a set of 2×2 contingency tables[2]. Little attention has been paid to the valuable information to be obtained from the subdivision of populations of this latter type. Goodall[3], working with vegetation, pointed out that such populations are divisible into "homogeneous" groups, in which all associations are either indeterminate (a given attribute being 0 or 1 in all members of the group) or below a predetermined significance-level. Unfortunately, he elected to divide by reference to a criterion which is inefficient, and which tends to produce final groups capable of ambiguous recombination.

The problem is to find the attribute which, at each stage of subdivision, is most likely to reduce the residual associations to their lowest possible level. At first sight, an attractive solution would appear to be to divide on the attribute with the highest loading, irrespective of sign, on the first principal axis of the correlation matrix. However, although finding this presents no difficulty on an electronic computer, it involves not only calculating but also storing all the elements of the matrix, thus seriously reducing the space available for the basic data (that is, the specified individuals). A similar objection applies to the corresponding element of the first centroid axis. Furthermore, it is by no means certain that the resulting division is the best for all purposes. As has been pointed out elsewhere in connexion with the ecological application of the problem[4], Goodall's definition of a "homogeneous group" depends ultimately on a significance test, the simplest of which for such purposes is the calculation of χ^2 with Yates' correction. If this criterion is in fact used, a preferable solution is to divide by reference, not to the correlation matrix, but to the corresponding contingency matrix. The correlation coefficients (r) can then all be taken with the positive sign, and the attribute with the highest $\Sigma |r|$ will necessarily be the attribute with the highest loading on the first centroid axis of the contingency matrix. (We prefer to use $|r|$ rather than r^2, the mean-square contingency itself, since it provides a closer analogy with factorial analysis; experience suggests that this does not discernibly reduce the efficiency of subdivision.) Since the $|r|$ values can be summed as they are obtained, it is necessary to provide only as many storage locations as there are attributes. Except for very large projects, ample space is thus available for both programme and data, and the subdivision can be made fully automatic.

We have therefore prepared, for the Ferranti 'Pegasus' computer, a programme which, from the specifications of all the individuals concerned, will carry out completely automatic subdivision into groups homogeneous at the $P = 0{\cdot}05$ level of significance. The highest χ^2 encountered during the examination of any group is printed out, thus permitting cross-comparison of all intermediate groups; and provision is made for disregarding any attributes which it is desired to exclude from the analysis. The programme exists in two alternative forms: the first will process up to 3,360 individuals specified by not more than 38 attributes, the second up to 1,680 individuals specified by not more than 76 attributes.

The resulting information may be used in several ways. Most important is the study of the structure of the homogeneous groups themselves, with particular reference to the disposition of those attributes not specifically used for subdivision. Secondly, as these latter attributes are inherently likely to be of importance in any subsequent factorial analysis, the fact that they are already known may well facilitate decisions on the placing of hyperplanes; in fact, we suspect that in some cases sufficient information may be obtained from the subdivision to render the far more laborious factorial analysis unnecessary. Lastly, if, as in ecological work, the individuals are of known distribution in space, the groups can be plotted on a map.

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Oct. 14.

[1] Burt, C., *Brit. J. Psychol.* (Stat. Sect.), **3**, 166 (1950).
[2] Slater, P., *J. Roy. Stat. Soc.* (Supp.), **9**, 114 (1947).
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Salt Excretion in Marine Birds

In connexion with recent research on salt excretion in marine birds[1,2] the following observation which I made some twenty-five years ago may be of interest. While cruising in a yacht far from land in the northern North Sea, I often used to watch lesser black-backed gulls as they soared above the ship or were perched on the mast head. I was very puzzled to account for a regular rain of drops of water which each bird shook at intervals from the tip of its beak. This was evidently salt excretion in action, and I know of no similar published account.

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Plymouth.

[1] Schmidt-Nielsen, Knut, and Sladen, W. J. L., *Nature*, **181**, 1217 (1958).
[2] Schmidt-Nielsen, Knut, and Fange, Ragnar, *Auk*, **75**, 282 (1958).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PSYCHOLOGIST (male, with a first- or second-class honours degree with psychology as the main subject or equivalent qualification) at the Ministry of Supply Clothing and Stores Experimental Establishment, Farnborough, Hants, to work in the Applied Psychology Section on the design of military equipment aiming at greatest efficiency, comfort and safety in its operation—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. G.409/8A (December 23).

SCIENTIST (MATHEMATICIAN, PHYSICIST or ENGINEER) (with at least a second-class honours degree or equivalent in an appropriate subject, and suitable research experience) AT DOUNREAY EXPERIMENTAL REACTOR ESTABLISHMENT, to lead a team responsible for mathematical physics calculations in connexion with the Fast Reactor and laboratory investigations of associated problems—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2797/T (December 29).

LECTURER (VETERINARY SURGEON) IN VETERINARY PATHOLOGY—The Registrar, The University, Liverpool (December 30).

LIBRARY ASSISTANT (Special Grade) (honours graduate, preferably with a diploma in librarianship and some previous library experience)—The Secretary of University Court, The University, Glasgow (December 31).

CHAIR OF NUCLEAR ENGINEERING—The Registrar, The University, Manchester 13 (January 1).

DEMONSTRATORS IN BIOCHEMISTRY AND NUTRITION and/or PHYSIOLOGY in the Faculty of Rural Science—The Registrar, University of New England, Armidale, New South Wales, Australia (January 1).

SECRETARY TO THE BRITISH TRUST FOR ORNITHOLOGY with offices at Oxford, for duties which include the supervision of field investigations, financial and office administration, correspondence with membership, attendance and speaking at meetings, and public relations—The Honorary Secretary, R. K. Cornwallis, British Trust for Ornithology, Bleasby Grange, Legsby, Market Rasen, Lincolnshire (January 1).

ASSISTANT IN RESEARCH (with an appropriate honours degree and preferably an interest in animal genetics) IN ANIMAL PHYSIOLOGY—The University, Downing Street, Cambridge (January 7).

SENIOR TECHNICIAN (with experience in the maintenance of colonies of animals) IN THE DEPARTMENTS OF BIOLOGICAL SCIENCES AND PHARMACY, to take charge of the animal house—The Registrar, Bradford Institute of Technology, Bradford 7 (January 7).

ASSISTANT LECTURER or LECTURER (with an honours degree in architecture and special knowledge of the application of scientific research to building construction) IN THE DEPARTMENT OF BUILDING SCIENCE—The Registrar, The University, Liverpool (January 10).

CHAIR OF GEOLOGY—The Secretary, The University, Exeter (January 17).

SENIOR LECTURER or LECTURER (with registrable medical qualifications) IN ANATOMY at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (January 26).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Secretary, The Queen's University, Belfast (January 30).

LECTURERS (2) (preferably, but not necessarily, experience of research work in experimental or theoretical nuclear physics) IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Liverpool (January 31).

I.C.I. RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY, PHYSICS, CHEMICAL TECHNOLOGY or CHEMICAL ENGINEERING—The Secretary, The University, Edinburgh (February 16).

I.C.I. RESEARCH FELLOWS IN CHEMISTRY, BIOCHEMISTRY, PHYSICS, ENGINEERING, CHEMOTHERAPY and related subjects—The Secretary, Academic Council, The Queen's University, Belfast (March 1).

ASSISTANT, Grade B (with a good degree) at the Municipal College of Technology and Commerce, Bournemouth, to teach mathematics principally to G.C.E. advanced level—Chief Education Officer, Town Hall, Bournemouth.

ASSISTANT BIOCHEMIST (B.Sc.) in the Fife District Laboratory, Windygates—The Medical Superintendent, East Fife Hospitals Board of Management, 243A High Street, Kirkcaldy.

ASSOCIATE PROFESSOR (with experience in both teaching and research) OF ELECTRICAL ENGINEERING in the School of Engineering, Carleton University, Ottawa, Ontario, Canada—Dr. J. G. Malloch, Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2.

BIOCHEMIST (with an honours degree in chemistry or biochemistry and preferably with experience of biochemical research), to carry out research on metabolic diseases of farm animals—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

CURATOR (between the ages of 25 and 35, at least B.Sc. zoology, preferably with entomological leanings) OF THE NYASALAND MUSEUM, to build up a museum exhibition from available collections and from collections to be made—The Secretary, Museum Board of Trustees, The Secretariat, Zomba, Nyasaland.

ECOLOGIST (with a good honours degree in botany and at least two years postgraduate experience or training in ecological survey methods including aerial photograph interpretation) in the Ministry of Agriculture, Northern Region of Nigeria, to be responsible for all vegetation aspects of the ecological, soil and land-use surveys currently being undertaken by the Northern Region Ministry of Agriculture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/408/012.

PHYSICIST or CHEMICAL ENGINEER (with a good honours degree and preferably some experience of research) IN THE BLAST FURNACE LABORATORY, Imperial College of Science and Technology, London, S.W.7, for laboratory and theoretical work on heat transfer and combustion problems—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "H.T.1".

SCIENTIFIC OFFICER (preferably BOTANIST/PHYSIOLOGIST) IN THE POMOLOGY (HORTICULTURAL BOTANY) DEPARTMENT, for work mainly on selective weed control; and a LIBRARIAN—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee.

STATISTICIAN (graduate, with suitable qualifications and experience, preferably including field trials)—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

TECHNICIAN (preferably with previous experience) IN THE CHEMISTRY LABORATORIES—The Secretary, Royal Holloway College (University of London), Englefield Green, Surrey.

TECHNICIAN (with experience in chemistry, and preferably some knowledge of glass-blowing) IN THE BIOCHEMISTRY AND CHEMISTRY DEPARTMENT—The Secretary, Guy's Hospital Medical School, London Bridge, London, S.E.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

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Microscopic Staining Techniques, No. 3. By Edward Gurr. Second edition. Pp. 62. (London: Edward Gurr, Ltd., 1958.) 6*s.*; 1 dollar. [1299

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